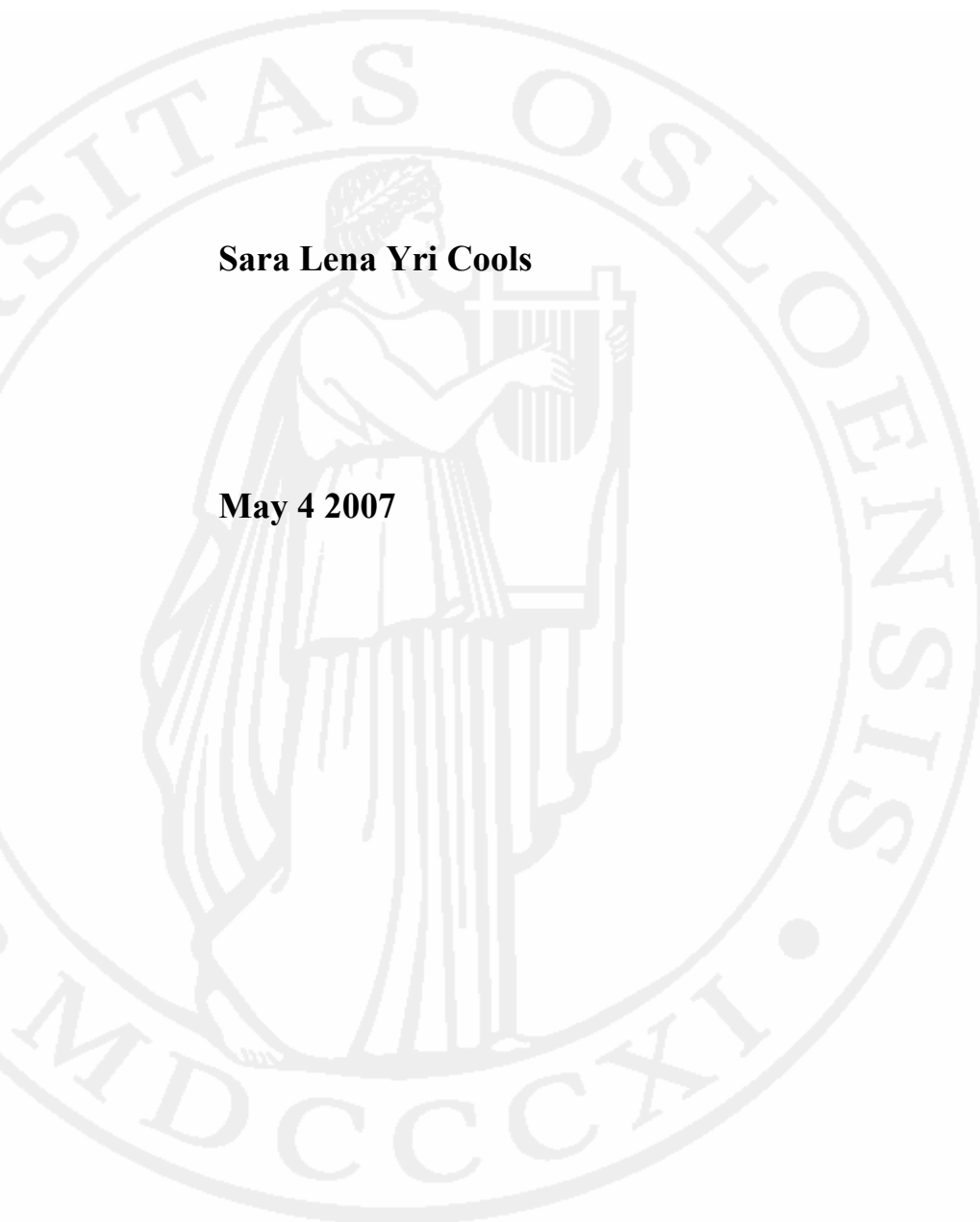


Master thesis for the Master of Philosophy in Environmental and Development
Economics degree

Assessing technology transfer in the Clean Development Mechanism

Sara Lena Yri Cools

May 4 2007



Department of Economics
University of Oslo

Preface

This thesis would not have been written without the help of my supervisor, Asbjørn Torvanger.

Thanks to family, friends and Jørgen Sissyfus. Thanks to fellow students – especially those from the Environmental and Development economics programme, who in the autumn of 2004 turned life at Blindern into a fairytale. And to Henning Wahlquist and Mona Frøystad for making the last weeks before deadline an increasingly cheerful experience.

Thanks to Kalle Moene, and to Jo Thori Lind.

Finally, I want to express my deepest gratitude to the kindness of Sverre Jensen and Steffen Kallbekken.

Table of contents:

PREFACE.....	1
INTRODUCTION.....	4
PART 1: INTRODUCTION ON THE CLEAN DEVELOPMENT MECHANISM.....	6
1.1 CLIMATE CHANGE AND CLIMATE POLICY AGREEMENTS.....	6
1.1.1 <i>Climate change</i>	6
1.1.2 <i>The UNFCCC and the Kyoto Protocol</i>	7
1.1.3 <i>The flexible mechanisms</i>	9
1.2 THE CLEAN DEVELOPMENT MECHANISM.....	10
1.2.1 <i>Objectives and expectations of the CDM</i>	11
1.2.2 <i>The CDM project cycle</i>	12
1.2.3 <i>Status of CDM projects</i>	13
1.2.4 <i>Critics of the CDM</i>	15
PART 2: ISSUES IN TECHNOLOGY TRANSFER.....	17
2.1 CONCEPTUAL COMPLICATIONS.....	18
2.1.1 <i>Definitions of technology transfer in economic literature</i>	18
2.1.2 <i>Understandings of technology</i>	19
2.1.3 <i>Related concepts: Technology diffusion and technology spillovers</i>	21
2.1.4 <i>Patterns and channels of technology transfer</i>	23
2.2 DEFINITIONS OF TECHNOLOGY TRANSFER IN CONNECTION TO THE CDM.....	25
2.2.1 <i>Haïtes et al. (2006)</i>	25
2.2.2 <i>TERI (2006)</i>	27
2.2.3 <i>Haake (2006)</i>	28
2.3 ‘INPUT’ OR ‘OUTPUT’ APPROACH? PRECONDITIONS VS. EFFECTS.....	30
PART 3: DEFINING TECHNOLOGY TRANSFER.....	32
3.1 THE VERBAL DEFINITION OF THIS THESIS.....	32
3.2 THE OPERATIONAL DEFINITION OF THIS THESIS.....	33
3.2.1 <i>Origin</i>	33
3.2.2 <i>Novelty</i>	34
3.2.3 <i>Improvement</i>	35
3.2.4 <i>Capacity</i>	37
PART 4: TECHNOLOGY TRANSFER IN THE CDM – POTENTIAL AND ACHIEVEMENTS.....	39
4.1 BARRIERS TO TECHNOLOGY TRANSFER.....	39
4.2 REASONS FOR THE CDM TO CONTRIBUTE TO TECHNOLOGY TRANSFER.....	41
4.2.1 <i>The CDM will stimulate investment</i>	41
4.2.2 <i>The CDM as mediator and facilitator</i>	42
4.2.3 <i>“Trade, not aid”</i>	43
4.2.4 <i>Involvement of the private sector</i>	44
4.3 EMPIRICAL RESULTS ON TECHNOLOGY TRANSFER UNDER THE CDM.....	45
4.3.1 <i>Technology transfer according to project size</i>	45
4.3.2 <i>Technology transfer for different project types and technologies</i>	46
4.3.3 <i>Technology transfer for different countries</i>	47
4.3.4 <i>Summing up</i>	48
PART 5: SIX INDIAN CASES.....	49
5.1 DESCRIPTION OF THE PROJECTS.....	50
5.1.1 <i>Two wind power projects</i>	51
5.1.2 <i>Two HFC oxidation projects</i>	53
5.1.3 <i>Two waste gas utilisation (WGU) projects</i>	55
5.2 CONCLUSION OF THE CASE ANALYSIS.....	58
5.2.1 <i>Summary of results</i>	58

5.2.2 <i>Implications for the specification of technology transfer indicators</i>	60
PART 6: CONCLUSION	61
APPENDIX	63
LIST OF ABBREVIATIONS	67
REFERENCES/LITERATURE	69

Introduction

The topic of this thesis is technology transfer in the Clean Development Mechanism (CDM). The ultimate question to be answered is: To what extent do CDM projects bring about technology transfer?

The importance of technology transfer is stressed throughout the texts of the Climate Convention. Technology will play an essential role both in mitigating and adapting to climate change. At present greenhouse gas emissions increase fastest in the developing world, which is also where the effects of global warming are expected to hit hardest. The most advanced technology both for mitigation and adaptation is largely to be found in developed nations.

Although the CDM has never been given an explicit mandate of technology transfer, its contribution in transferring technologies to developing countries is both hoped for and exacted. It is also expected by analysts – and a few quantitative studies have found evidence of it.

In order to answer the question of technology transfer in the CDM, however, two preliminary questions need answering. First of all, what is technology transfer? Secondly, how to define technology transfer in a way that could be used in empirical investigations of the CDM?

Answering these two questions has been the main task of this thesis. The first is a question of definition, the second a question of making the definition *operational* in relation to the CDM.

In order to answer the first question, several definitions given of technology transfer were consulted. It quickly became clear that there is no general agreement as to what technology transfer is.

Different perspectives on technology transfer are discussed in Part 2 of this thesis, with a special focus on definitions that have been used in connection to the CDM. Part 2 also looks further into the concept of technology, and distinguishes ‘transfer’ from the related concepts ‘diffusion’ and ‘spillovers’.

The second question is answered in Part 3, which gives an operational definition of technology transfer, stating four criteria that need to be satisfied. In doing so, special attention is paid to the specification of indicators for each criterion, according to

- i) relevance: is the indicator truly an indicator for the criterion in question?

- ii) clarity: does the indicator allow one to decide dichotomously whether the criterion is satisfied or not?
- iii) information: does the indicator allow one to decide whether the criterion is satisfied or not given the available information?

The question of technology transfer in the CDM is then the topic in Part 4, which looks into the literature on technology transfer in relation to the CDM. Arguments that have been given in favour of the potential of the CDM as a technology transferring mechanism are related. The results of three studies of technology transfer in the CDM are discussed.

In Part 5, the first steps are taken towards a quantitative analysis of technology transfer in the CDM based on the definition established in Part 3. The definition is tested out on a small set of six Indian cases, but due to lack of information, the analysis is not able to identify technology transfer with certainty. However, this problem is not considered to immediately invalidate the operational quality of the definition, as time shortage was the main reason for the lack of information.

The CDM and the background on which it was established are explained in Part 1.

Part 6 concludes this thesis.

Part 1: Introduction on the Clean Development Mechanism

This part gives a description of the Clean Development Mechanism (the CDM) and the background on which it was established.

1.1 Climate change and climate policy agreements

Section 1.1.1 gives a short explanation of the problem of anthropogenic climate change, before the two major documents of international climate policy – the UNFCCC and its Kyoto Protocol – are described in Section 1.1.2. Section 1.1.3 introduces the three flexible mechanisms of the Kyoto Protocol.

1.1.1 Climate change

Energy from the sun makes life on earth possible. Sunlight enters the atmosphere in the form of short-waved radiation. About half of it is absorbed by the earth's surface. As the earth is heated by the absorbed sunlight, and by indirect radiation from the atmosphere, it emits *long-waved* radiation. Greenhouse gases (GHGs) in the atmosphere – most importantly *water vapour* (H₂O), *carbon dioxide* (CO₂), *methane* (CH₄), and *nitrous oxide* (N₂O) – let short-waved sunlight pass through, but absorb the long-waved heat radiation and re-emit it in all directions, thereby causing a natural 'greenhouse effect'¹. In this way they keep average global temperature about 33°C higher than it would otherwise be.²

Because of greenhouse gas emissions caused by more than 150 years of industrialization and the, global atmospheric concentrations of CO₂, CH₄ and N₂O have increased markedly, and they do now far exceed pre-industrial levels. The global increases in CO₂ concentration are due primarily to extensive and increasing burning of fossil fuels and the concomitant cutting of forests, while those of CH₄ and N₂O are primarily due to agricultural methods (IPCC, 2007). If greenhouse gas emissions continue to rise at their current pace, they will most probably double (maybe even triple) their concentration in the atmosphere compared to pre-industrial levels (UNFCCC Homepage).

The result of the increase in atmospheric greenhouse gas concentrations is that the heat given off from the earth's surface is further delayed in its escape into space, causing the temperature on earth to rise. The Intergovernmental Panel on Climate Change (IPCC) concludes that it is

¹ The analogy to a greenhouse is not actually correct, but the term prevails.

² The earth's energy balance is illustrated in Figure A-1 in the appendix.

highly probable (more than 90%) that “the globally averaged net effect of human activities since 1750 has been one of warming” (IPCC, 2007). Estimates of the expected rise in average global temperature vary, but even the IPCC ‘best case’ scenario – a 1.8° C to 4.0° C rise by the year 2100 – would have grave consequences for life on earth³.

1.1.2 The UNFCCC and the Kyoto Protocol

As climate change is inevitable due to past and current emissions, the efforts to tackle it must be twofold: Current emissions need to be reduced in order to limit anthropogenic global warming. And serious adaptation measures must be put in place in order to reduce the impact of the adverse changes in climate that cannot be avoided.

The United Nations Framework Convention on Climate Change (the UNFCCC⁴) states as its “ultimate objective” the “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system” (UNFCCC, 1992; Article 2). The convention did not contain any binding emissions reductions commitments. Such commitments were established with the adoption of the Kyoto Protocol⁵ to the Convention in 1997.

Article 3 of the Protocol commits ‘Annex I parties’⁶ to reduce their overall emissions of greenhouse gases by at least five per cent below 1990 levels in the first commitment period 2008-12 (UNFCCC, 1998a). This corresponds to a targeted reduction yearly of 713 million tonnes of CO₂e compared to 1990 emission levels (TERI, 2005).

CO₂-equivalent (CO₂e) is the unit used in specifying emission limits for each country. For each greenhouse gas a ‘Global Warming Potential’ (GWP)⁷ has been specified by the IPCC to be used in emissions accounting. The GWPs are used in translating emissions of any gas into CO₂-equivalents. The greenhouse gases listed in Annex A of the Protocol are, in addition to carbon dioxide, methane and nitrous oxide, *hydrofluorocarbons* (HFCs), *perfluorocarbons* (PFCs) and *sulphur hexafluoride* (SF₆). Their GWPs as calculated in IPCC (2001) are listed in Table 1.

³ Only to mention some: Extinction of numerous plant and animal species, severe storms, floods, droughts and precipitation events, heat waves, plummeting agricultural output and the expansion of ocean volume.

⁴ The text of the convention, UNFCCC (1992), will generally be referred to as ‘the Convention’.

⁵ This protocol, UNFCCC (1998a), will generally be referred to as ‘the Kyoto Protocol’ or just ‘the Protocol’.

⁶ ‘Annex I parties’ are industrialised countries listed in Annex I to the Convention. As their emission reductions were specified in Annex B to the Protocol, they are sometimes also referred to as ‘Annex B parties’ (or ‘Annex B countries’).

⁷ The GWP is the *cumulative radiative forcing effects* of a gas over a specified time horizon (a hundred years for the values given in Table 1), resulting from the emission of one unit mass of gas relative to a reference gas (CO₂ in this case). (U.S. EPA Homepage).

Table 1: Global warming potential of greenhouse gases. Source: EPA (2006)

GHG	GWP in IPCC (2001)
Carbon dioxide (CO ₂)	1
Methane (CH ₄)*	23
Nitrous oxide (N ₂ O)	296
HFC-23	12 000
HFC-125	3 400
HFC-134a	1 300
HFC-143a	4 300
HFC-152a	120
HFC-227ea	3 500
HFC-236fa	9 400
Perfluoromethane (CF ₄)	5 700
Perfluoroethane (C ₂ F ₆)	11 900
Sulphur hexafluorid (SF ₆)	22 200

The Kyoto Protocol states quantified emission limitations and reduction commitments for the Annex I parties. The limitations are given in Table 2, expressed as percentage change relative to the 1990 emission level for each country⁸. The Protocol entered into force on February 16, 2005. Of the signatories, two important emitters of greenhouse gases – the U.S. and Australia – never ratified the treaty. From 2006 Canada has a new Conservative government that has expressed its wish to withdraw from the Protocol.

Table 2: Countries included in Annex B to the Kyoto Protocol and their emissions targets. Source: UNFCCC Homepage.

Country	Target (1990 - 2008/2012)
EU-15 ⁹ , Bulgaria, Czech Republic, Estonia, Latvia, Liechtenstein, Lithuania, Monaco, Romania, Slovakia, Slovenia, Switzerland	-8 %
US	-7 %
Canada, Hungary, Japan, Poland	-6 %
Croatia	-5 %
New Zealand, Russian Federation, Ukraine	0 %
Norway	1 %

⁸ Some of the countries with ‘economies in transition’ (EITs; Central and East European countries and former republics of the Soviet Union that are in transition to a market economy) have a baseline other than 1990.

⁹ The EU’s 15 member States will redistribute their targets among themselves, taking advantage of a scheme under the Protocol known as a “bubble”. The EU has already reached agreement on how its targets will be redistributed.

Australia	8 %
Iceland	10 %

1.1.3 The flexible mechanisms

In the negotiations leading up to the Kyoto Protocol several governments¹⁰ agitated fiercely for allowing as much flexibility in achieving emission reductions as possible – in order to achieve national reduction goals at a lower cost. Among the flexibility provisions are the three Kyoto flexibility mechanisms; ‘emissions trading’ – already a well-known mechanism – and the generation of tradable emission reduction units through either ‘joint implementation’ or ‘clean development mechanism’ projects¹¹. Any Annex I party having ratified the Protocol, and that has a national emissions accounting system in place, may use the mechanisms to achieve extra greenhouse gas emission ‘credits’ that can be counted against its own target¹².

The **joint implementation mechanism (JI)**¹³ under Article 6 allows an Annex I party to count against its assigned emission target emission reduction units (ERUs) that have been generated by implementation of projects that reduce emissions of greenhouse gases (or increases greenhouse gas removals by sinks) in the territory of another Annex I party.

In practice, JI projects are most likely to take place in the “economies in transition” among the Annex I parties, as there tends to be more scope for cutting emissions at low cost in these countries. The first JI project was only recently approved, at the end of March 2007 (Point Carbon 28.03.07).

The **clean development mechanism (CDM)** under Article 12 allows an Annex I party to count against its assigned emission target emission reduction units that have been generated by implementation of projects that reduce emissions of greenhouse gases (or increases greenhouse gas removals by sinks) in the territory of a non Annex I party that is a party to the Protocol.

¹⁰ Australia, Canada, Iceland, Japan, New Zealand, Norway, the Russian Federation, Ukraine, and the U.S.A.

¹¹ The other flexibility provisions are: A multi-year commitment period for six greenhouse gases (meaning that it is the *average* yearly reduction of the *total greenhouse gas* emissions that matters), the possibility of *banking* and the *‘bubble option’* (Woerdman, 2004).

¹² Annex I countries’ governments are responsible for complying with the emissions targets (albeit with the opportunity of handing reduction commitments down onto private companies), but the *use* of the mechanisms, such as investing in JI or CDM projects or trading in emission credits, is not restricted to Annex I governments; investors and traders can also be private actors and they do not have to come from an Annex I country.

¹³ Although the JI mechanism is defined in Article 6 of the Protocol, the term ‘joint implementation’ does not appear in the Protocol.

The emission reduction units generated through the CDM are called “certified emission reductions” (CERs). The CDM will be discussed at length in Chapter 1.2.

The **emissions trading scheme (ET)** under Article 17 allows an Annex I party to transfer some of their assigned amount units (AAUs) to another Annex I party that finds it relatively more difficult to meet its emissions target.

Parties may also transfer CERs, ERUs or RMUs¹⁴ that have been acquired through the CDM, JI or sink activities. The Marrakesh Accords require Annex I Parties to hold a minimum level of AAUs, CERs, ERUs and/or RMUs in a commitment period reserve that cannot be traded, in order to ensure that countries do not “over-sell” and end up being unable to meet their own targets. (UNFCCC Homepage)

As part of their preparations to meeting the Protocol targets, the EU and Norway already have schemes in place regional and national emission trading, but a *Kyoto* Emission Trading scheme open to all Kyoto signatories has not yet been implemented.

In theory the Kyoto mechanisms would lead to an “equalisation of marginal abatement costs evaluated at the chosen CO₂e emission or emission credit level throughout the world” (Flottorp and Kråkenes, 2005). In practice, however, the Protocol requires that the use of the mechanisms only be “supplemental to domestic action” (UNFCCC 1998a) and transaction costs to the use of the mechanisms are expected to be significant (TERI, 2005; Michaelowa and Jotzo, 2005). Also, many Annex I countries do not have an approved national emissions accounting system in place, and will not be allowed to trade in Kyoto units until they do¹⁵.

1.2 The Clean Development Mechanism

As outlined above, the basic principle of the CDM is that investors can receive CERs for emissions reductions achieved in a non-Annex I country. This chapter describes the mechanism more in detail.

¹⁴ Removal units, generated in Annex I countries by LULUCF (land use, land-use change and forestry) activities that absorb carbon dioxide.

¹⁵ Most importantly this concerns Russia, which is expected to hold a significant excess of AAUs due to industrial decline after the negotiations of the Kyoto emission targets. If they do not get an accounting system in place, the much discussed issue of trade in ‘hot air’ (excessive AAUs) will have less importance.

1.2.1 Objectives and expectations of the CDM

The flexible mechanisms were incorporated into the Protocol under the aegis of cost efficiency. But the CDM has an additional purpose: “to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention” (UNFCCC, 1998a; Article 12). Exactly how this will happen is not specified, but expectations are that the CDM may contribute to sustainable development in a number of ways. Hopes have even been stated that developing countries may “leapfrog” past the unsustainable technological development stages of the industrialised world (Aslam, 2001). The main idea is that the CDM will stimulate foreign direct investment (FDI) – and investment in general – in greenhouse gas reducing projects, thereby causing a less carbon-intensive development in non-Annex-I countries (Kjellén et al. in Haake, 2006).

It is however recognised that the sustainable development contribution does not follow automatically from the CDM. All countries that wish to host CDM projects must therefore decide on a set of sustainable development requirements that CDM projects have to satisfy in order to be approved by the Designated National Authority (DNA). As each host country has the prerogative to determine its own sustainable development criteria, the selected criteria may however vary a great deal across host countries (UNDP).

Most host countries do also include specific requirements for the transfer of technology among these sustainable development criteria¹⁶. Technology transfer is urged repeatedly throughout the texts of the Convention and the Kyoto Protocol, and it is discussed again in Agenda 21. The CDM was never explicitly identified in these texts as a means of fulfilling their technology transfer objectives. Nevertheless, it has generally been expected to be an important channel in this respect as it provides financing opportunities to the investment in and adoption of low-emission energy technologies in developing countries, where ‘ESTs’ (Environmentally Sound Technologies) generally are not state-of-the-art technology (Wilkins 2002, Haites, Duan and Seres 2006, Haake 2006, UNDP). The potential for CDM as a technology transferring vehicle will be further discussed in Chapter 4.2.

Expectations are also tied to the involvement under the CDM of the private sector in the climate change issue, as it is expected that most Annex I countries will pass emission limitations on to their private sector.

¹⁶ The results of Haake (2006) do however point to a potential trade-off between the degree of technology transfer and sustainable development respectively in CDM projects.

1.2.2 The CDM project cycle

“5. Emission reductions resulting from each project activity shall be certified by operational entities to be designated by the Conference of the Parties serving as the meeting of the Parties to this Protocol, on the basis of:

- (a) Voluntary participation approved by each Party involved;
- (b) Real, measurable, and long-term benefits related to the mitigation of climate change; and
- (c) Reductions in emissions that are additional to any that would occur in the absence of the certified project activity.” (UNFCCC, 1998a; Article 12.5)

The CDM is defined in Article 12 of the Kyoto Protocol, but its administrative structure and the basic rules for registering and validating CDM projects were elaborated first in the Marrakech Accords of 2001 (TERI, 2006).

The main document in the CDM project process is the ‘Project Design Document’ (PDD) that describes the project activity and the technologies involved, and assesses the overall effects of the project – economic, social, technological and environmental – with a special regard to greenhouse gas emissions. This is the ‘application’ of the project developer that is submitted to be validated. Before the PDD can be submitted, however, the project developers must obtain confirmation by the host country DNA that the project contributes to sustainable development, together with an “approval of voluntary participation from involved Parties” (CDM Watch).

In order to get the emissions reductions certified, the project developers need to prove in the PDD that their project involves a reduction in emissions that would *otherwise not have occurred*. This is called establishing *additionality* of the project. To prove that the project is additional, first a *baseline scenario* forecasting emissions in the absence of the project is established and is then compared to the *project scenario* – a forecast of emissions if the project is approved¹⁷. The difference in emissions between the two scenarios is what can be claimed as CERs. Then project developers need to prove that the project would not be feasible in the absence of the CDM, i.e. that there is some barrier – financial, technological, legal or institutional – to the project that is overcome (only) through the CDM, for instance that it is not profitable without the supplemental revenues obtained by selling of the CERs.

¹⁷ The baseline scenario is established in accordance with methodologies developed and approved by the CDM Executive board (EB).

As it would be in the interest to both the investor and the host party to exaggerate emissions reductions accruing from a proposed project there is a risk of awarding spurious credits (Michaelowa and Dutschke, 1999). Parties to a project must therefore choose an accredited independent organization – a ‘Designated Operational Entity’ (DOE) – that will validate the proposed project and certify emission reductions. After validation, the final step is to get the project registered by the CDM Executive Board (EB). If a project is registered and implemented, the EB issues the CERs to project participants based on the monitored difference between the baseline and the actual emissions. (CDM Watch)

There are thus several institutions involved in the validation and accreditation process, most of which are international. The host country’s involvement is all channelled through its DNA. Both project developers, at several points in the process, as well as the EB in establishing baseline methodologies, are required to solicit input from the public or from stakeholders to the project (CDM Watch).

1.2.3 Status of CDM projects

The first CDM project was registered in November 2004¹⁸. As of April 11 2007 the total number of registered projects was 621, while 65 more were requesting registration. According to the UNEP Risø CDM pipeline, by April 1 2007 the CDM pipeline counted 1804 projects at various stages in the process, yielding an expected number of CERs of nearly 2 billion until the end of 2012¹⁹ (Fenhann, 2007).

The distribution of all registered projects in the pipeline according to host country is given in Table A-1 in the appendix. India, Mexico and Brazil have large shares when it comes to numbers of projects, whereas China is hosting projects involving high amounts of CERs and therefore has 40% of the average sum of CERs to be issued yearly. Both India and Mexico have an average size of CDM projects below half the average of all projects.

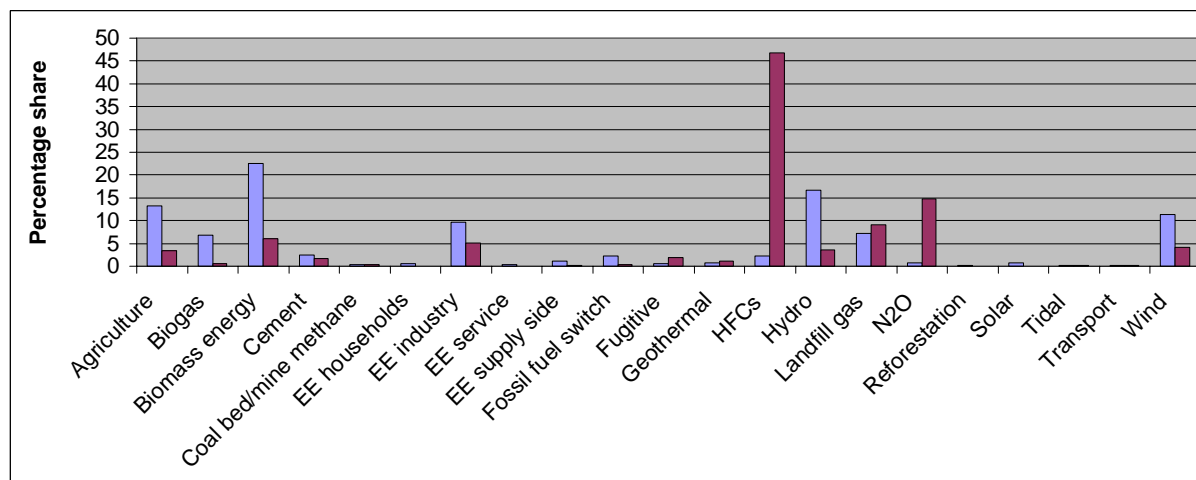
The distribution of all registered projects according to project type is given in Table A-2 in the appendix, and in Figure 1 below. The sectors with the most projects are *biomass energy* and *hydropower* projects. The average project size in these sectors is small however compared to the overall average project size. Reduction of HFCs and N₂O emissions stand out in this

¹⁸ “The Protocol envisages a prompt start to the CDM, allowing CERs to accrue from projects from the year 2000 onwards. This prompt start was put into effect at COP 7, with the establishment of the CDM’s executive board.” (UNFCCC?)

¹⁹ Assuming no renewal of crediting periods.

respect. Though counting low shares of total projects (just above 3%), these sectors together make up almost two thirds of all CERs to be issued yearly.

Figure 1: Distribution of projects by project type. Blue columns show percentage share in total number of projects, purple columns show the percentage share in numbers of CERs issued yearly. Source: Fenhann (2007)

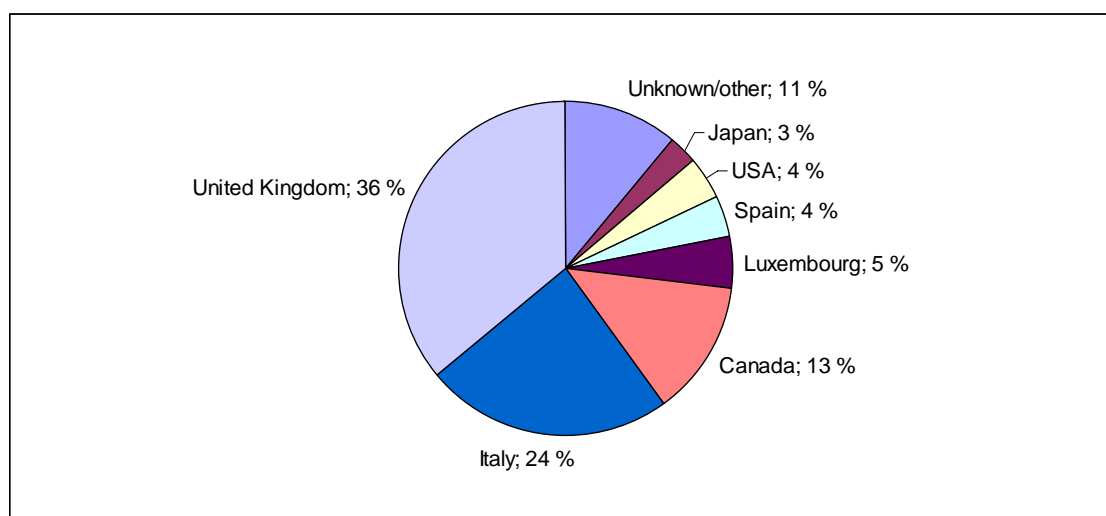


Point Carbon (2007) offers summary statistics on the trade in CERs in 2006. According to their analysis, 58% of the CERs in 2006 were bought by private actors, whereas only 8% by governments (mainly European). Funds made up the last 34%.

That financial institutions have become active in the market is reflected in the chart of buyer countries, reproduced in Figure 2. Much of the market activity out of the UK is financial and not compliance-driven, which is obviously also the case for Luxembourg – and the US (primarily due to the World Bank funds)²⁰ (Point Carbon, 2007).

²⁰ Also, the Greenhouse Gas Credit Aggregation Pool's (GG-CAP) HFC-23 purchases are the sole reason why Canada figures on the list. Italy's high position stems from ENEL's procurement of CERs from HFC-23 and other projects in China, as well as the Italian government's activity through the World Bank.

Figure 2: Origin of CER buyers. Source: Point Carbon (2007)



1.2.4 Critics of the CDM

As a *financial mechanism concerning reductions in greenhouse gas emissions* involving the participation of both *developing and industrialised nations*, with a special regard to *sustainable development* – as defined by the individual host country, it shouldn't come as a surprise that the CDM has faced criticism at nearly all levels. This section goes through the major criticisms that have been expressed, from renouncing altogether the motivation behind it, through objections to the shape it was given and to the dissatisfaction concerning its concrete results.

Most fundamentally, strong criticism has been expressed towards the idea itself of achieving/increasing cost efficiency through the CDM in the fight against global warming²¹. As the CDM allows Annex I countries to buy 'atonement' through emissions reductions in the developing world while continuing along a non-sustainable path of energy consumption and greenhouse gas emissions, instead of taking the domestic action that is necessary, it has been considered a major escape from responsibility. Furthermore, concern has been expressed that developed countries through the CDM will exhaust the cheap present abatement options in developing countries (referred to as 'low hanging fruit'), and leave only the more complex and expensive options for later when developing countries will also be given emission caps (Haake, 2006).

One step up, accepting the idea behind the CDM, its design has been criticised as unsuitable for accomplishing what are its stated objectives; additional emission reductions and

²¹ The flexibility mechanisms were opposed throughout by environmental NGOs and initially also by developing countries (Wikipedia).

sustainable development in the developing world. Concerning additionality, the literature on *carbon leakage*²² is already abundant.²³ The weighting of the different greenhouse gases according to their estimated GWP is also seen to cause an overproduction of CERs through HFC- and N₂O-destruction projects.

Regarding sustainable development, specific CDM projects and project types of projects have been criticised for their adverse contribution to sustainable development. This especially concerns particular dam/hydropower projects and HFC destruction projects in India and China.

In response to the criticism of the CDM design, the WWF has developed a “CDM Gold standard” to ensure that the CDM deliver “credible projects with real environmental benefits” representing “new and additional investments in sustainable energy services” (WWF Homepage)

Another criticism concerns the CDM project cycle, which is considered to be unnecessarily complicated and costly, posing several barriers to project developers in requiring a great deal of skill in project developers, being potentially very time consuming and involving a significant amount of transaction costs. (Babu and Michaelowa, 2003; TERI, 2006) In addition, there is a fee on the trade in CERs that does not have an equivalent in the trade in ERUs or AAUs. This may seriously weaken the attractiveness of the CDM as carbon credit provider relative to the other flexible mechanisms.

Lastly, the CDM has also faced criticism for its achievements, which by some have been considered disappointing. First of all, it has been criticised for being too small. Secondly, the CDM is criticised for having too skewed a distribution, leaving out the least developed countries most in need for investment and technology transfer. Finally, the degree of technology transfer generally in the CDM has been deemed unsatisfactory. The relationship between technology transfer and the CDM will be the topic in Part 4.

²² That the reduction in CO₂ emissions by Annex I countries will be partly offset by an increase in emissions in other countries. (Di Maria and van der Werf, 2006)

²³ However, carbon leakage estimates in Kallbekken (2006) indicate that earlier estimates of carbon leakage may have been exaggerated. Studies do even exist that indicate a negative carbon leakage.

Part 2: Issues in technology transfer

Technology will play an essential role both in mitigating and adapting to climate change. The now developed nations have been important emitters of the greenhouse gases causing the global warming that is already being observed. It is also the developed nations that have the most advanced technology both for mitigation and adaptation. The developing world, on the other hand, is where greenhouse gas emissions increase fastest, technology and investment capital is scarce, and where the effects of the global warming will do the most harm. There is thus a moral backdrop to urging the transfer of technologies from developed nations to the developing world. However, as the greenhouse effect of emissions does not depend on where they take place, it may also be in the self-interest of the developed nations that such transfers occur insofar as they contribute to reductions in greenhouse gas emissions at a lower cost.

On this background, several calls for technology transfer were written into the Climate Convention, with special responsibility placed with “developed country Parties”. The calls were reiterated in the Kyoto Protocol²⁴. However, in contrast to the national emission targets that were settled on in the Protocol, no legally binding measures to ensure technology transfer have yet been decided. As already indicated, the CDM has in this context often been identified as a – if not *the* – means of fulfilling the deeply urged, and deeply needed, transfer of relevant technology to developing nations.

The role of the CDM in transferring technologies is the topic in Part 4. However, in order to assess its role in this respect, one needs to know what is meant by technology transfer.

Unfortunately, there is no clear answer to that; technology transfer has been taken – and given – to mean quite a range of different things.

The purpose of this part is to arrive at a clearer understanding of what technology transfer is, and how it could be measured. This will be done in the following way: Chapter 2.1 goes through various definitions that have been given for technology transfer, but it also pays attention to the concept of technology, and on the distinction between technology transfer and

²⁴ Summarised in Haites et al. (2006): “Article 4.1 of the Convention requires all Parties to promote and cooperate in the development, application and diffusion, including transfer, of greenhouse gas mitigation technologies.² Articles 4.3 and 4.5 stipulate that developed country Parties should provide new and additional financial resources to support the transfer of technology and take all practicable steps to promote, facilitate and finance the transfer of, or access to, environmentally sound technologies and know how to developing country Parties. Article 11.1 of the Convention further prescribes that financial resources shall be provided for the transfer of technology on a grant or concessional basis. Article 10(c) of the Kyoto Protocol reiterates the requirement of all Parties to cooperate in the development, application, diffusion and transfer of environmentally sound technologies that are in the public domain.³ Article 11.2 of the Protocol repeats the commitment of developed country Parties to financial resources for technology transfer.”

the related concepts ‘technology spillovers’ and ‘technology diffusion’. Chapter 2.2 gives special attention to three definitions of technology transfer that have been used in studies of technology transfer in the CDM. Chapter 2.3 discusses two different approaches for assessing technology transfer; the ‘input’ vs. the ‘output’ approach.

2.1 Conceptual complications

Most articles that treat the topic of technology transfer more than purely theoretically, point to the fact that definitions of technology transfer vary and that an authoritative source doesn’t really exist²⁵. To studies of technology transfer in connection to the Climate Convention, the IPCC would be the natural holder of such authority. But, as will be shown in Chapter 2.2, the definition provided in the report “Methodological and Technological issues in Technology Transfer” (IPCC, 2000) is generally dismissed as being too vague to be made operational in empirical investigations.

The sections of this Chapter go through some fundamental conceptual issues of ‘technology transfer’. In Section 2.1.1 the range of technology transfer definitions is illustrated by three examples from the economic reference literature. Section 2.1.2 provides a discussion of the concept of technology. In Section 2.1.3 the sibling terms technology diffusion and technology spillovers are discussed, whereas 2.1.4 looks into different channels for the spread of technology.

2.1.1 Definitions of technology transfer in economic literature.

It will be useful in the following to have a preliminary idea of how technology transfer is defined. To illustrate the spectre of definitions that have been given, I have chosen to use three definitions from the economic reference literature:

Technology Transfer:

“In the broadest sense the exchange among countries of the knowledge of the existence of and of the operations of types of machinery and in many cases of the machinery itself.” *Macmillan dictionary of modern economics* (Pearce, 1992).

“The generally deliberate moving of research and development results into a different setting in the same society or another for private or public use.” *International Encyclopedia of Economics* (Magill, 1997).

²⁵ “Definitions of technology transfer differ much.” (Haake, 2006) “There is surprisingly little consensus on what constitutes technology transfer. In fact, in much of the discussion of technology transfer, the term is not defined.” (Kline et al., 2003). “The literature shows a broad array of definitions” (de Coninck et al., 2007)

“The transfer of techniques from countries where they are more advanced to other countries where they are less advanced. Technology transfer may involve foreign direct investment, transfers of skilled personnel from more advanced countries, training of workers from less advanced countries, or licensing of patents. Technology transfer is of great importance to less developed countries, who have most to learn, but it is useful to all countries, since no one country is the leader in every branch of technology.” *The Oxford Dictionary of Economics* (Black, 2003).

Whereas the first definition stresses the exchange between countries, the second one points to the generally deliberate character of the exchange, while the last one assesses the technological level of the originating vs. the recipient party to the transfer – and adds an evaluating note.

The definitions point to four questions that all should be answered when defining ‘technology transfer’: Does the transfer need to be international? Does it have to be intended, or will it happen as a by-product of normal market transactions? Does it need to involve a technological improvement to the recipient party? And need it be beneficial?

I will return to these questions when ‘technology transfer’ is defined in Part 3.

2.1.2 Understandings of technology.

The nature of technology itself – the object of the transfer – is a fundamental issue in defining technology transfer. ‘Technology’ has been given an incredible number of definitions of various lengths. At its broadest, it is *how you perform a particular activity*. In economics, the broad definition is *what transforms ‘inputs’ into ‘outputs’* (or what transforms ‘resources’ into ‘goods’ and ‘services’).²⁶

The phenomenon causing this transformation thus is increasingly seen as having both ‘hard’ and ‘soft’ aspects. The hardware part consists of basic technical physical equipment. Software is somewhat harder to pin down, as it is exactly everything about the technology that is not physical, it is “knowledge, practices, understanding *etc.*” (Nordqvist, 2005). One could say that the software of a particular technology is what makes its hardware work.²⁷ However, as parts of the one and same technology – the ability to perform a particular activity – one might as well say that the hardware lets the software work.

²⁶ “Technology. A piece of equipment or a technique for performing a particular activity.” (www.gcricio.org), “A firm’s technology is the processes it uses to turn inputs into outputs of goods and services” (www.safarix.com)

²⁷ Both aspects are actually necessary in order for the denotation of the term ‘technology’ to be consistent with the functional definitions mentioned above.

The hardware parts of technology are necessarily *embodied*. What they are embodied in is what in economics is usually called ‘physical capital’. The two terms are thus not the same; physical capital is not technology, but when essential parts of the technology are embodied in physical capital it will nevertheless be an indispensable part of the technology.

Knowledge and praxis (software) need not be embodied, but they may be. When embodied in humans, it is often called ‘human capital’ or simply skill. Software may however also reside outside of persons, disembodied, for instance in written form.

Nordqvist (2005) draws the distinction between, on the one hand, explicit (“or codified”) knowledge – such as instruction manuals, safety routines or impact assessment – and, on the other hand, *tacit knowledge*. Explicit knowledge could be disembodied as well as embodied, but tacit knowledge could only be embodied.

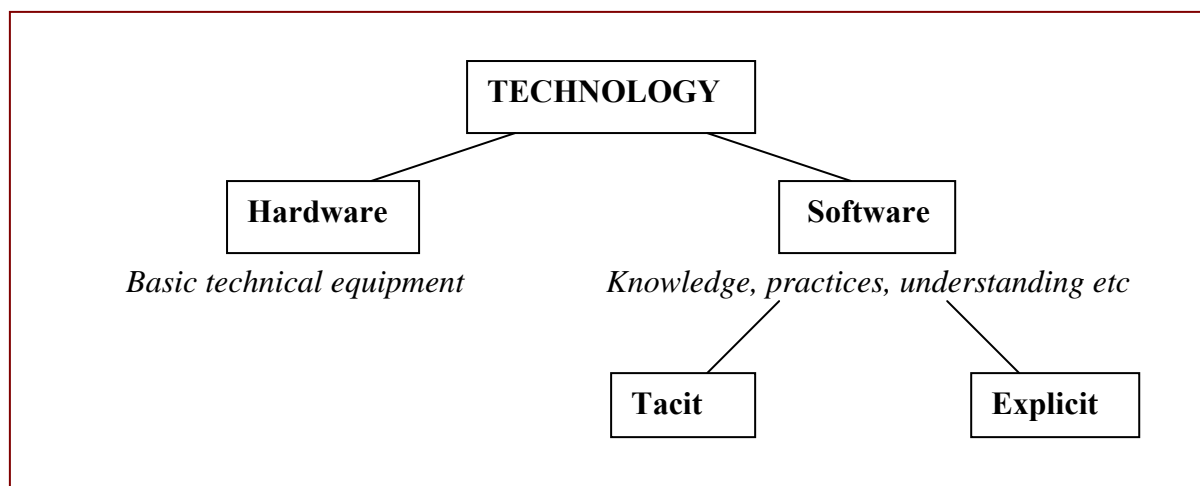
The term tacit knowledge originates with Polanyi (1958). “Knowledge is to some extent tacit because the person who is actively engaged in a problem-solving activity cannot necessarily define (and hence prescribe) what exactly she is doing” (Keller, 2004). It involves learning and skill but not in a way that can be written down; it denotes those aspects of knowledge that can only be transmitted via training or gained through personal experience. It can also be knowledge that is embedded in a culture and therefore difficult to share with people from outside that culture. Tacit knowledge is often called ‘know-how’ (Wikipedia).

How technology is construed will naturally influence the ways in which it could be transferred. The part played by tacit knowledge in technology is probably what is most complicating its transfer. (This will be further discussed in Chapter 2.1.4.)

Summing up what has been said in this section: *Functionally*, technology is what allows one to achieve a certain end with the help of certain inputs (such as labour and capital).

Substantially, a given technology will consist of different parts; physical equipment, explicit knowledge and tacit knowledge. They are illustrated in Figure 3.

Figure 3 The different aspects of technology.



Technology thus conceived has two features that are worthwhile pointing out in relation to its transfer: First of all: Technology is *more than* the physical equipment – therefore technology transfer involves more than placing physical capital in a new context. This is hardly controversial; yet, much theoretical work, and politics in practice, on technology transfer does not seem to take it into proper account²⁸.

Secondly: Technology is *also* the physical equipment. This is important pointing out to distinguish technology transfer from the mere spilling over of knowledge. The physical equipment is essential to the operation of many technologies, and it is usually costly, even after the costs of invention have been paid, to reproduce and maintain²⁹.

Hence, *all* the aspects in Figure 3 will be considered essential to ‘technology’, and technology transfer should therefore not be defined without giving special consideration to how technology can be transferred *in its entirety*.

2.1.3 Related concepts: Technology diffusion and technology spillovers

‘Technology transfer’ is closely related to the two terms ‘technology diffusion’ and ‘technology spillovers’. Often, both in economics and elsewhere, the three terms are used interchangeably, and most of the time their conceptual difference is not stated clearly. Further complicating the picture, ‘knowledge’ or ‘R&D’ are often used synonymously with

²⁸ Political writings would be where it is actually taken into account: IPCC (2000): “It may be worth repeating that technology is not simply a patent or a piece of equipment, but knowledge, processes and practices.” IEA (2001): “Technology transfer is *not* simply about the supply and shipment of hardware across international borders. It is about the complex process of sharing knowledge and adapting technology to meet local conditions. It strengthens human and technological capacity in developing countries. It promotes commercial markets for climate-friendly technology.”

²⁹ From what has been said also follows that technology is *not* a public good; it is neither non-excludable (due to its tacit knowledge-parts and the legal protection possibilities of codified knowledge), nor entirely non-rival (due to its hardware parts).

‘technology’ (especially when it comes to technology spillovers). A short clarification on this latter issue will be given here, before trying to pin down the different meanings of the three sibling terms from the cases where they have been used more consciously.

The relationship between knowledge and technology was already discussed in the previous section. Knowledge constitutes an important part of technology, but technology is not only knowledge. Nor is all knowledge technological.

R&D – ‘Research and Development’ – could be described as the process that produces knowledge – and technology.

‘Technology diffusion’ usually refers to the geographic spread of a technology. The spread of any part of technology, be it only machinery or only knowledge, could happen as diffusion. Trade in intermediate goods would be one example of technology diffusion in this sense (as would the propagation of hand washing among midwives in the first half of the 19th century).

What distinguishes technology diffusion from technology transfer is that technology diffusion seems faceless, whereas technology transfer involves two parties to the transfer – a ‘transferer’ and a ‘transferee’. The focus of the technology diffusion literature is rather the extent and geography of the spread; origin and destiny matter may matter, but sender and recipient do not.

Technology diffusion could also be the next stage after a technology has been successfully transferred, and ultimately the sign of a successful transfer. Once a new technology has been introduced in a society, the further spread later on within this society would be diffusion. Diffusion could thus be decoupled from the origin of the technology, and it does not necessarily concern a technology that is *new* within a given context. As will be seen in chapter 2.3, origin and novelty will be deemed necessary criteria in the definition of technology transfer.

‘Technology spillovers’ is an externalities concept, denoting the positive externalities to R&D; the production of knowledge and technology. “... while there is a force that might be strong enough to sustain the private incentive to innovate ... technological investments may also create benefits to firms and individuals external to the inventor by adding to their knowledge base ... These benefits are usually called knowledge spillovers.” (Keller, 2001)

As spillovers are externalities, only software parts of the technology could spread as spillovers. Spillovers are part of the diffusion of knowledge, but knowledge could also diffuse without spilling over, as when it is paid for in the form of education or buying of blueprints.

A subtype of spillovers, are the ‘rent spillovers’ (Griliches, 1979) that denote the difference between what you pay to get hold of a technology and what the alternative cost would be of inventing it yourself. Because of large fixed costs and close to zero marginal costs, there will often be rent spillovers to the trade in technology. But there will generally also be additional costs to the recipient party – learning costs – even though the inventor does not receive this as payment.

What distinguishes technology spillovers from technology *transfer* is that spilling over happens passively; it is not an action, whereas transferring something is.

Summing up what has been said in this section: ‘technology transfer’, ‘technology diffusion’ and ‘technology spillovers’ all denote a common phenomenon: The spread of technology. But they focus of different aspects, both of the technology and of the spreading process. Whereas the focus of ‘*diffusion*’ is the extent of the spread, and the spread itself, ‘*transfer*’ puts the focus on the transaction, and ‘*spillovers*’ are externalities to the ‘production’ of knowledge.

2.1.4 Patterns and channels of technology transfer

Different conceptions of technology will have an influence on how it is thought to spread. But even for a consistent conception, technology spreads in a number of ways. It could be given away, sold, stolen or spilled over.

Market transactions: As with any trade, trade in technology presupposes protection of property rights. Hardware parts can readily be traded on a market (or be given away). Soft technologies can also be sold or given away, but they would have to be made explicit in order to be protected by legal rights. Tacit knowledge is both harder to protect and harder to transfer than its explicit counterparts.

Where the technology is protected by intellectual property rights, Kaplinsky (1990) lists five market transactions that may serve as “applicable delivery mechanisms”:

- i) Transfer of equity in a company possessing the desired technology,
- ii) license agreements with owners of the technology,
- iii) purchase of equipment containing the technology,
- iv) paying directly for the know-how involved (e.g. as blueprints),
- v) and hiring personnel in whom the technology is ‘embodied’ (i.e., who possess the requisite knowledge about the technology).

Spilling over: According to Keller (2004), many economists believe that technology spillovers are more important to international diffusion of technology than trade in intermediate goods (Keller, 2004; p.758). As stated, only the software parts of technology could spread as spillovers. As new information and communications technologies evolve and also in themselves become an important sector of the economy, one would expect the importance of spillovers to increase, both because, in these technologies, software parts make up a larger share relative to hardware parts compared to other technologies, and because these technologies themselves facilitate the spilling over of technologies.

Such an evolution ought nevertheless not to inspire expectations of the free spread of technology, not even its software parts. Keller (2004) lists why:

“First, irrespective of feasibility, it is not in the interest of the original inventor who has incurred the R&D cost to send it to others at no charge. On the contrary, the inventor may decide to spend additional resources to keep the technology secret. Second, even if some domestic technology becomes available abroad, it may be possible to preclude others from using it by patenting the technology. Third, even if the technology is non-rival and can be moved from one country to another at zero marginal costs, operating the technology efficiently often requires making costly investments in terms of complementary skills.”

The first two reasons concern the issue of intellectual property protection, which is seen as a hindrance to the free spilling over of knowledge. According to Kline et al. (2004) it also constitutes a major barrier to the transfer of technology. However, poor intellectual property protection in a country may also be a barrier to technology transfer in discouraging technology suppliers from investing in projects in the country (see Chapter 3.1).

The last reason listed concerns the problems of transmitting tacit knowledge. “Technology is only partially codified because it is impossible or at least very costly to fully codify it” (Keller, 2004). Therefore, even if all parties involved desire to transfer the technology it will not happen without costs; Teece (1977) estimated within-firm transfer costs of multinational companies providing technology to their subsidiaries to be on average almost 20 percent of the total project costs (Keller, 2004).

‘Theft’: Technologies are also said to spread through *theft*; reverse engineering or industrial espionage. As spillovers have been defined here, reverse engineering and industrial espionage, insofar as they do not involve theft of the physical capital, would actually be kinds of spillovers.

Keller (2004) sums up the implications of the nature of technology on the patterns for technology diffusion:

“The partial codified nature of technology means that technology diffusion will be incomplete, and technology stocks in different countries will vary. Diffusion will tend to be more geographically localized the higher is the non-codified share in total technology.

Because international economic activities (trade, FDI, etc.) lead to additional contacts with foreign persons who may possess advanced technological knowledge (exporter, importer, engineers, researchers), this may stimulate the diffusion of (non-codified) foreign technology. Trade and interaction with multinationals may thus lead not only to technology diffusion of the limited kind (technology embodied in intermediate goods), but it may also raise the probability of international R&D spillovers.”

2.2 Definitions of technology transfer in connection to the CDM

Three definitions from the economic reference literature were given in Section 2.1.1. This chapter will look at three definitions that have been used more specifically in empirical investigations of the CDM. To my knowledge, these are the only three quantitative studies that to date have been carried out on technology transfer under the CDM³⁰.

They all use different definitions of technology transfer, but common to all three is that they refer to the definition given by the IPCC before choosing a more operational definition for their empirical investigations. The IPCC definition is given below:

“In the Report the term "technology transfer" is defined as the broad set of processes covering the flows of knowledge, experience and equipment amongst different stakeholders such as governments, private sector entities, financial institutions, NGOs and research/educational institutions. The broad and inclusive term "transfer" encompasses diffusion of technologies and technology cooperation across and within countries. It comprises the process of learning to understand, utilise and replicate the technology, including the capacity to choose it and adapt it to local conditions.” (IPCC, 2000)

2.2.1 Haites et al. (2006)

Haites et al. (2006) goes through the PDDs of 854 proposed CDM projects for which public comments had been solicited prior to 20 June 2006, and check them for claims made to technology transfer. The claims were coded for the nature of the technology transfer activity

³⁰ In addition to the ones discussed below, de Coninck, Haake and van der Linden (2007) also have a study, to a large extent based on the results of Haake (2006). Haites et al. will present a new study in May 2007

(imported equipment, training local staff, etc.) and sorted into different categories. The categories and the claims falling into them are given in Table 3.

Table 3: Categories of technology transfer claims. Source: Haites et al. (2006)

<p>Transfer of Equipment Only</p> <p>Equipment transferred from foreign sources / Import of equipment</p>
<p>Transfer of Knowledge Only</p> <p>Development of local equipment suppliers and/or engineering consultants firms</p> <p>Training of local staff members about foreign technology</p> <p>Technical capacity building through involvement of local partners, staff, firms</p> <p>Technical capacity building by observing external experts implementing project</p> <p>Partnership between foreign technology supplier and local entities</p>
<p>Transfer of Equipment and Knowledge</p> <p>Equipment and knowledge transferred from foreign sources</p> <p>Combination of indigenous and foreign technology</p> <p>Equipment transferred from foreign sources and Development of local equipment suppliers and/or engineering consultants firms</p> <p>Equipment transferred from foreign sources and technical capacity building through involvement of local partners, staff, firms</p> <p>Equipment transferred from foreign sources and Technical capacity building by observing external experts implementing project</p> <p>Equipment transferred from foreign sources and Signing of maintenance and/or operations contract with foreign equipment supplier</p> <p>Equipment transferred from foreign sources with Partnership between foreign technology supplier and local entities</p> <p>Equipment transferred from foreign sources and knowledge transferred through the development of local equipment suppliers and/or engineering consultants firms; training of local staff members about the foreign technology; and technical capacity building through involvement of local partners, staff, firms</p>
<p>Other</p> <p>Technology transfer facilitated through intermediary entity with long term technical transfer agreement (agreement is independent of project)</p> <p>Foreign supplier is granted all rights to implement the CDM project activity</p>

Project using domestic equipment with foreign management model

In Haites et al. (2006), the claims are used as indicators of technology transfer – no further investigation is done into whether the claims reflect “reality”. They do however rule out projects that claim technology transfer for technology that is already available in the country, on the grounds that “the focus of the Kyoto Protocol is on technology transfer between countries” (Haites et al., 2006).

The main reason behind the choice of technology transfer indicator is one of practicality³¹. Though far from ideal, this is useful in its own right as Haites et al. are able to assess ‘instances’ of technology transfer for a large number of CDM projects. It is also worth taking note of their stand on whether technology transfer should be considered *intra-* or *international* in connection to the CDM.

2.2.2 TERI (2006)

The Energy and Resources Institute (TERI) carried out a study the same year, scrutinising the 171 registered CDM projects as of May 1, 2006. Pointing out, exactly as Haites et al. do, that although later versions of the prescribed PDD format explicitly ask participants to state whether the project involves technology transfer the term is left undefined, they reach the opposite methodological choice; that of “not [restricting themselves] to examining the response of project participants to this question while identifying the occurrence of international technology transfer” (TERI, 2006). Instead they make, in their own words, a simplification of the IPCC (2000) definition, and consider “a CDM project to have resulted in International Technology Transfer (ITT) if it *explicitly involved the use of climate-friendly technology whose rights (patents, licenses, trademark or copyright) are owned by a foreign actor, or in which expertise possessed exclusively by a foreign actor is shared with the project proponents*”. They add that this may be achieved “through imports, technology collaboration or assistance, joint ventures or Foreign Direct Investment” (TERI, 2006).

To TERI as well, the reason for their simplification is one of practicality. “Determining whether and how ‘flows’ of know-how, equipment and experience have occurred in a particular project would require numerous interviews and detailed analysis ... beyond the

³¹ “Given the large number of registered and proposed projects, it is not practical to define “technology transfer” and then ensure that any claims are consistent with that standard definition.” (Haites et al., 2006)

scope of this work”. They point out some interesting characteristics of their definition as they have chosen it.

The first is that their definition considers a “weak form” of technology transfer, as it “does not require the transfer of ability to *replicate* technology – the ultimate stage of technology transfer”. Secondly, their definition “does not require technology transfer to be purely altruistic”; as it “includes transfer of technology through *commercial transactions* between firms”. Thirdly, they do not require international technology transfer to be advantageous to the host country. “While it seems reasonable that a domestic firm would only import when [the technology transferred is in some way superior to domestic technology], this need not always be the case.” (TERI, 2006)

2.2.3 Haake (2006)

Haake (2006) presents a “three-tiered” operational definition, where the different tiers represent ever stricter forms of technology transfer. The first and weakest tier holds technology transfer to be taking place whenever “the ‘hard’ technology originates from a European country”³².

At the second tier, “technology transfer takes place once the technology implemented is not from the host country itself, was not available in the host country before or it was available but will be improved” (Haake, 2006). A “state-of-the-art”-criterion is also added, requiring that the technology is “in an advanced form and [is not] regarded as older in industrialized countries”. This does however not open up for using the host country as testing grounds for technology that is completely new, thereby “taking on the technology risks from the more able industrialized countries”. The conclusion is that there needs to be a balance; the technology should be neither too new nor too old. Technology that is not allowed in Annex-I countries is also ruled out (Haake, 2006).

The third tier includes transfer of know-how. It builds on a definition given in Wilkins (2002): “technology transfer can be defined as the diffusion and adoption of new technical equipment, practices and know-how between actors ... within a region or from one region to another”.

Haake specifies two rather concrete criteria to be used when testing for technology transfer in this sense. The first one is “capacity building required for operation and maintenance of the project”. As ‘capacity building’ is generally a long-term concept it is hard to evaluate whether

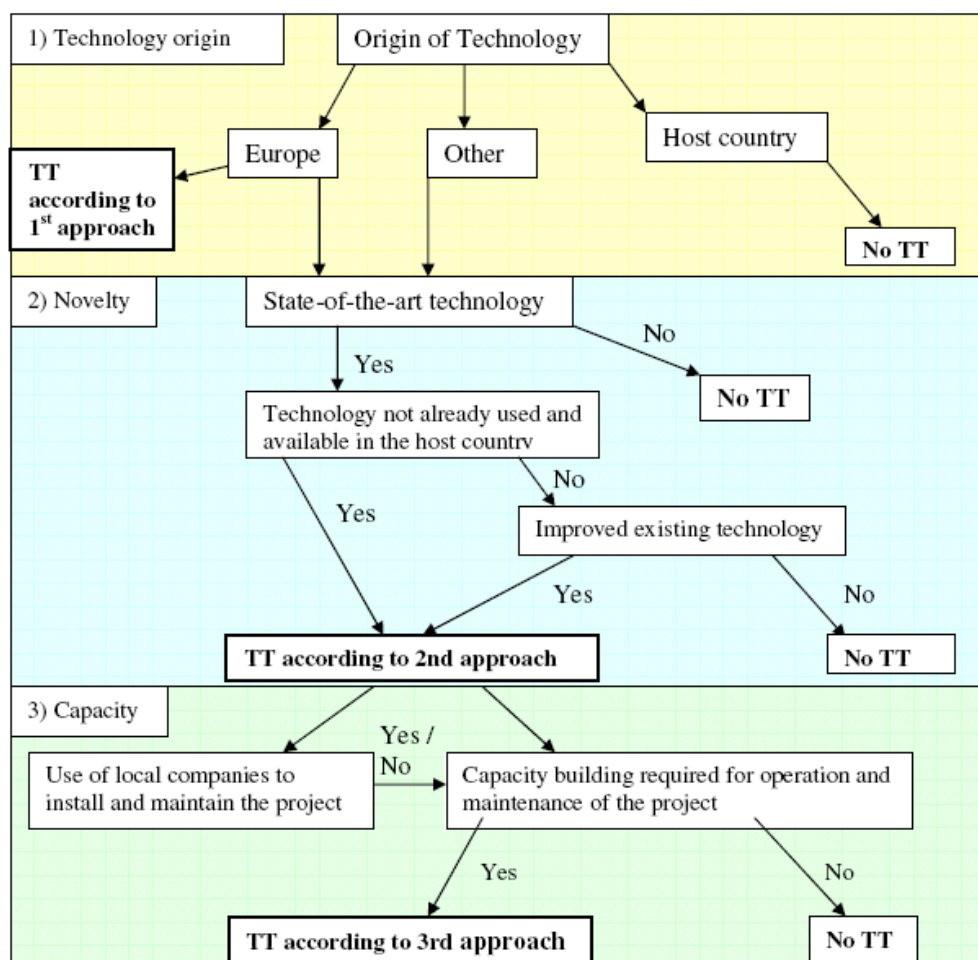
³² Although this may seem irrelevant to our purpose, in practice most foreign CDM-investors in Haake (2006) are from Europe.

it has taken place in the context of something as young as the CDM and therefore the criterion is meant to test whether it is actually *needed* – with the hope that this will be an indicator of it actually coming into place.

The other criterion of the third tier is “use of local companies to install and maintain the project”. The reasoning behind is that if local companies “at least” are involved during the installation of the project they will gain some knowledge by it unless they already possess all the relevant knowledge. This is seen to guarantee the ability of locals to maintain the technology on their own; either they’re already able or they have learnt what they need during the installation. The criterion is not decisive to her definition, however, it is “used for making the criterion of capacity building stronger or weaker. In the case that local companies are involved, but no knowledge is transferred, it seems that knowledge transfer is not necessary. Another case might be that local companies are involved and knowledge is transferred at the same time, which would strengthen the criterion of knowledge transfer.”

Finally, Haake illustrates her definition in a figure, reproduced in Figure 4 below.

Figure 4: Three-tiered definition of technology transfer in Haake (2006)



2.3 ‘Input’ or ‘output’ approach? Preconditions vs. effects.

One may want to measure technology transfer for different reasons. The ultimate objective of this thesis is to establish a definition that is useful for assessing the degree of technology transfer among CDM projects; to decide, for each project, whether or not technology transfer has occurred, and, if possible, whether it is a weak or strong form of technology transfer. Such an objective warrants an ‘input approach’, looking for the ‘inputs’ to technology transfer: stating conditions that, when met, are sufficient to affirm technology transfer. With this approach incidences of technology transfer can be identified and its frequency can be quantified, but little can be quantified with respect to the further effects of technology transfer on the technological capacities of the recipient country or community.

Often, it may rather be exactly the further effects of the technology transfer – its ‘output’, or its *value* – that is of interest. Increase in productivity is one such output – considered to be very *valuable*. In order to measure the effects of technology transfer on productivity one would have to look at the broader picture, and consider effects over time.

This approach is the most common when it comes to economic studies of technology transfer, technology spillovers and technology diffusion. The main branch is termed the “R&D spillover regressions” literature (Keller, 2001). Here one tries econometrically to estimate the effect on domestic productivity of technology and knowledge ‘production’ abroad. The proxy for productivity is usually total factor productivity (TFP), whereas the proxies for foreign technological level vary (Cincera and van Pottelsberghe de la Potterie, 2001; Lichtenberg and van Pottelsberghe de la Potterie, 2001).³³

These studies measure by proxy the effects of any kind of technological spread, and it would be hard to separate the effect attributable to technology transfer only – which is what is of interest in this thesis. In connection to the CDM there are three further reasons why an ‘output approach’ is less suitable. The CDM is first of all too young and secondly too small compared to overall investments in a country, to have its effects captured – and isolated – in for example in regressions testing the effect of foreign technological capital on changes in total factor productivity (TFP). Thirdly, usual measures of productivity, be it TFP or other quantities, are based on conventional methods for estimating GDP. The CDM will (presumably) contribute to the transfer of technologies the main purpose of which is not contributing to economic

³³ Being the externalities part to knowledge production or R&D activity, they have also been the object for purely theoretical modelling. In this literature, technology spillovers can be modelled just like any other type of externality; for instance as a simple parameter. This is done in Golombek and Hoel (2004), where the impact of environmental technology spillovers on the viability of international climate agreements is studied.

productivity growth, but to ‘environmental productivity’ (something that would be captured through Green National Accounting (GNA)).

This is not to say that the ‘effectiveness’ of technology transfer under the CDM could not be assessed through an input approach. IPCC (2000) lists four groups of criteria for effective technology transfer, some of which are “amenable to quantitative evaluation”.

Part 3: Defining technology transfer

Based on the discussions and definitions of Part 2, the task at hand is twofold: Firstly, to define technology transfer, and secondly, to make the definition operational so that it can be used in empirical investigations of technology transfer under the CDM. The second task is carried out in Chapter 3.2. Chapter 3.1 just states the ‘verbal form’ of the definition chosen for this thesis.

This means first of all to specify criteria that need to be satisfied in order to prove technology transfer. Secondly, for each criterion, an indicator needs to be pinned down that is considered suitable for assessing technology transfer specifically in relation to the CDM considering both the information available on CDM projects and the type of technology typically involved.

A short note first on how much ought to be included in a definition of technology transfer. It has already been pointed out that there are moral issues tied to the transfer of technology. In my opinion a definition is more useful when it does not have too many normative stands baked into it, as they may end up diluting the meaning of the concept. One of the questions asked in 2.1.1 was whether technology transfer needs to be beneficial to the recipient party. This is not included as a specific criterion in the definition to follow. Such an evaluation ought to lie outside of the concept of technology transfer itself. On the contrary I have chosen to include technological improvement as a criterion, another question asked in Section 2.1.1. However, as will be shown in Section 3.2.3, this is not based on a normative evaluation of the transfer.

3.1 The ‘verbal definition’ of this thesis

The general formulation of the definition is:

Technology transfer takes place when a **new** and **improved** technology **originating outside** a community is brought into use in the community, and when the **ability to operate, maintain and control** the new technology is also transferred to the members of the recipient community.

‘Technology’ here is broadly understood, covering both ‘soft’ and ‘hard’ technologies, and the transfer may happen intentionally as well as as a side-effect, on commercial as well as on concessionary terms.

3.2 The operational definition of this thesis

The definition in Chapter 3.1 includes four main criteria that can be categorised as ‘*origin*’, ‘*novelty*’, ‘*improvement*’ and ‘*capacity*’³⁴. The sections to follow go through each of these categories³⁵. In each category one criterion is stated, and for each criterion an indicator is specified. The choice of indicators is based on three ‘selection criteria’: *relevance* (is the indicator truly an indicator for the criterion in question?), *clarity* (does the indicator allow one to decide, *dichotomously*, whether the criterion is satisfied or not?) and *information* (does the indicator allow one to decide whether the criterion is satisfied or not given the information available?)

3.2.1 Origin

Criterion: *The technology originated abroad.*

Indicator: *The technological equipment is imported from abroad, or it is manufactured in the host country but the rights to the technology (patents, licenses, trademark or copyright) are owned by foreign actors.*

Discussion:

In order for there to be talk of technology transfer, the technology ought to come from somewhere outside of the context it is transferred to. This is a standard assumption in definitions of technology transfer, but different practices apply concerning the requirements on how ‘foreign’ the technology needs to be³⁶. The main choice is usually between international and *intranational* technology transfer. According to the IPCC (2000), the bulk of technology transfers occur within the countries where the technology was generated.

There is not really a normative stand on this; the choice ought to depend on whether you wish to study international or intranational technology transfer. But one ought nevertheless to make a conscious choice on this. What distinguishes technology *transfer* from mere diffusion (which may be what the IPCC were referring to), is that it involves a stronger focus on the two parties to the transfer: the sender and the receiver. Hence, choosing between inter- and intranational technology transfer is choosing how or whether to specify these parties. Haites et

³⁴ Although not entirely overlapping, this categorisation is strongly inspired by Haake (2006).

³⁵ The fact that there is one indicator for each criterion and just one criterion in each category is a coincidence and is not to be considered an important feature. In addition to wishing to add categories, one may wish to include more criteria in a category, or to specify more indicators for the same criterion – something which was also considered during the deliberations leading up to the final form of the definition.

³⁶ “Are knowledge spillovers international or intranational in scope?” (Branstetter, 1996)

al. (2006) points to the fact that “the focus of the Kyoto Protocol is on technology transfer between countries” – and many would probably add “from the developed to the developing world”.

A problem with ruling out technology transfer inside a country is that in a big and diverse country, such as India, the spread of technology within national borders may be just as important. In cases where new technology was invented in another region very different in relevant characteristics (such as R&D level), it may be that the criterion ought to be modified to include interregional transfers. Cases in which the technology was invented abroad and has already been imported to one region of the country, and in which it then spreads from this region to another ought however rather to be considered as instances of technology *diffusion* – an indicator of successful transfer in the previous stage, but not itself another instance of technology transfer.

As is clear from this criterion; even in the case of international technology transfer, the equipment (the hard technology) would not necessarily have to be manufactured abroad. It is sufficient that the technology was invented abroad, for there to be talk of technology transfer. Neither is it necessary to go as far as requiring what TERI (2006) called “the ultimate stage of technology transfer”; the transfer of ability to *replicate* a technology³⁷. The ability to replicate a certain technology (technology A), may be considered a different technology (technology B) than the one to be replicated (technology A).

3.2.2 Novelty

Criterion: *The technology is new in the country, region or community in question.*

Indicator: *The technology in question is not already in use in the country.*

Discussion:

That a technology could not be *transferred* to a community already employing the technology is obvious. But just as in the last section, it is not as obvious that national borders are the most appropriate to define the new context of the technology. Last section distinguished interregional technology transfer from interregional technology diffusion. Another question is whether a technology could be transferred to the same country more than once, for instance

³⁷ This is taken even one step further by the IPCC (2000), when suggesting as a test of transfer is that the ‘transferee’ gains the ability to “choose and adapt the technology to the local socio-economic environment and raw materials, and to sell to someone else the original technology with improvements”.

whether the transfer of a foreign technology to two different regions in the host country should be considered as two or one instances of technology transfer.

This is a relevant problem in connection to the CDM. As the CDM marks a jump in investment in certain types of technologies in developing countries, it is not unlikely that separate CDM projects in the same country choose to import the same technology at short intervals in time.

Therefore the above indicator should be used with discretion. The main rule is that the technology should not already be in use in the country, but it may be modified to requiring that the technology should not have been in use in the country for more than a certain amount of time³⁸.

Sometimes the distinction is drawn between new technologies and improvements in existing technologies. As improving a technology involves changing it, and usually involves adding new parts that are in themselves ‘technology’, improved technologies will to our purpose be considered new technologies.

Haake (2006) and the national CDM requirements of among others Cambodia and Indonesia set a limit as to *how new* the technology to be transferred may be, reflecting the concern that developing countries should not be used as testing ground for new technologies³⁹. Such a limit may be in place, but for other reasons than asserting technology transfer. It is therefore not obvious that it should impact on the definition of ‘technology transfer’.

The indicator chosen identifies ‘new technologies’ as technologies that are not already in use. In order to distinguish a technology from the ones already in use, one would however need to specify in which respect the new technology needs to be different from the others. This is done by the next criterion and its chosen indicator.

3.2.3 Improvement

Criterion: *The technology to be used is better than technologies already in use in similar projects.*

Indicator: *The technology is more environmentally efficient than alternative technologies in use.*

³⁸ Projects take long to plan (and diffusion is thus a stage in successful transfer). Therefore, one should ideally rule out technology that is already in use, but in some cases it may be necessary to look at how prevalent the use is.

³⁹ Cambodia requires that the technology should be “well proven” (IGES, 2005) and Indonesia that it should not be “experimental” (NC CDM Indonesia Homepage)

Although when urging technology transfer the aim is most probably the transfer of *better* technologies than the ones already available, that the new technology be an improvement compared to existing technologies does not follow directly from a semantic discussion of the technology transfer concept.

Several host countries make demands on the quality of the technology in their sustainable development criteria. In the case of Kenya, Indonesia and Pakistan, the main concern is avoiding ‘technology dumping’⁴⁰, a precaution that may seem in place given the not so bright history of previous international technology transfer endeavours⁴¹. In the case of India and Cambodia, the demands are higher, comparable to the “state-of-the-art”-criterion in Haake (2006)⁴². The criterion chosen for this thesis differs from these demands in that it rates the new technology only with respect to the technology already available in the host country.

The reason for choosing to include improvement as a criterion here, however, is not a normative one. The choice of indicator under novelty was that the technology in question was not already in use. In order to decide which technologies are different from each other, one must make a choice of in what respect they ought to differ. In the case of technology transfer, *improvement* seems the most relevant respect.

The choice of indicator seems the most relevant in the case of technology transfer under the CDM; for a technology to be better – and thereby different (new) – it ought to be environmentally more efficient. As such the ‘improvement’ represented by the new technology is isolated to concern only the performance of the technology, thereby avoiding the broader discussion on whether the technology is beneficial.

‘Environmental efficiency’ could be divided into ‘impact efficiency’ and ‘resource efficiency’. Increasing impact efficiency means that the production of a certain amount of output will have less negative impact on the environment as a by-product (i.e. will cause less greenhouse gas emissions). Increasing resource efficiency means that the production of a certain amount of output will require less use of scarce resources. For the technology to be

⁴⁰ The Kenyan Government Guidelines to the CDM states that all CDM projects must “have necessary precautions in place to avoid dumping of substandard technologies” (Pembina Institute, 2003), while Indonesia and Pakistan require that CDM projects that are to be approved do not use “obsolete” technologies.

⁴¹ Cf. the “Convenient Dumping Mechanism” (Aslam, 2000)

⁴² Indian authorities require that “the CDM project activity should lead to transfer of environmentally safe and sound technologies (...) that are comparable to best practices in order to assist in upgradation of the technological base” (Government of India Homepage). Cambodia, that has a more complex method for assessing fulfilment of the criteria, awards a positive score for transfer of the “best available technology in advanced industrial economies”, whereas zero points – just enough for approval – is handed out for the transfer of “standard technology used” (IGES, 2005).

more efficient according to the above criterion, then, it will have to be more efficient in at least one of these two respects – and it should not be less efficient in any of them. (Cases where there is a trade-off between environmental and resource efficiency would have to be given special consideration, but in general they should not be considered to involve an *improved* technology.)

Satisfying the demands voiced by India and Cambodia above could qualify the technology transfer as ‘improvement-strong’ (increasingly so for technology that is i) standard technology in developed countries (or at least as efficient as the sector average in the investor country), ii) the best available in the investor country, or iii) the best available in all of the developed world). However, there is an important trade-off between getting the most advanced technology and satisfying the criterion specified for ‘capacity’ in the next section.

3.2.4 Capacity

Criterion: *The capacity to operate and maintain the technology is also transferred to the community.*

Indicator: *Local employees will be the ones operating and maintaining the technology throughout the project.*

This criterion is meant to ensure that essential ‘soft’ technology is not left out of the transfer. The physical equipment can of course be ‘transferred’ simply by being placed in a new setting. ‘Codified and explicit’ manifestations of the soft technology could also easily be handed over (a technical manual, for instance), but explicating knowledge can be costly and time consuming. In many cases the knowledge on how the equipment and the technology work is an indispensable part of the technology itself, and generally such knowledge can not in its entirety be made explicit (or at least it would be very expensive to do so). Important parts of this knowledge will therefore remain tacit. The “transfer” of tacit knowledge is of course impossible to guarantee, just as it is impossible to verify, but participating in the installation, the operation and the maintenance of the technical equipment at least secures the possibility for know-how to be transferred.

The indicator is chosen somewhat in line with the reasoning in Haake (2006); demanding that special training has been offered to local employees could rule out cases of technology transfer where such training is not needed. Indicators of training could be that local employees take part in the installation or that they are given explicit training. But requiring that locals operate and maintain the technology seems a wiser choice of indicator as one does not risk

ruling out cases of technology transfer, *and* one can reasonably expect that workers that are to be trusted with the operation or maintenance of the technology would have to have or get the necessary qualifications. Satisfying the training-indicators mentioned above could however qualify the technology transfer as ‘capacity-strong’⁴³.

This criterion also serves an important function in the trade-off between using local workers to ensure the transfer of technology’s softer parts, and having “improvement-strong” technology transfer. In requiring local workers to operate the technology during the project, it would either be the case that the gap between local capacity and that required for the operation of the new technology is not too big, or project developers will have to provide training of local staff, either in the form of participation during the installation, or by additional schooling – or both.

⁴³ The time span of the project could be another qualifier of ‘capacity-strength’. As capacity building is something that is done over time, longer lasting projects would have more scope for capacity building.

Part 4: Technology transfer in the CDM – potential and achievements

This part will look into the discussion of technology transfer in the CDM from two angles. It has already been mentioned several times that hopes have been high that the CDM will bring about the transfer of environmentally sound technologies to the developing world⁴⁴. To some, such hopes have reflected a normative stand on the issue: The CDM *ought to* bring about technology transfer because that is partly why it was established. The same reasoning that has led several host countries into incorporating technology transfer in their national CDM sustainable development criteria. But regardless of moral imperatives; what role *can* and what role *does* the CDM play in the transfer of technology? The question is thus twofold:

- i) How, given its current features, would one expect the CDM to contribute to technology transfer?
- ii) What are the results of studies that have tried to assess the degree of technology transfer in the CDM?

The first question will be answered in Chapter 4.2. Chapter 4.3 gives a summary of the findings of the three studies that have been carried out on technology transfer in the CDM. But before answering these questions, Chapter 4.1 will give a short discussion of why transferring technologies is considered such an arduous task.

4.1 Barriers to technology transfer.

In the broader literature on technology transfer, *barriers* to the transfer of technologies have been given much attention. As with ‘technology transfer’, the precise definition of the term ‘barrier’ is disputed, but it may generally be defined as any factor inhibiting the technology transfer process (Wilkins, 2002; UNFCCC, 1998). As such, barriers to technology transfer would exist anywhere between the originating and the recipient party, but the focus is usually with barriers in developing countries. Overcoming the barriers in the recipient country to the implementation of a new technology is usually referred to as creating ‘enabling environments’.

UNFCCC (1998) lists eight categories of barriers relevant to the transfer of ESTs. The list is given in Table 4, and will be referred to in the discussions of Chapter 4.2. A systematic

⁴⁴ The scope for technology transfer through the CDM concerns mitigation technologies, it does not provide much incentives for investment in adaptation technologies

discussion of what would be the contribution of the CDM with respect to each of these barriers is provided in Haake (2006).

Table 4: Barriers relevant to the transfer of ESTs. Source: UNFCCC (1998).

(a) Institutional:	lack of legal and regulatory frameworks, limited institutional capacity, and excessive bureaucratic procedures;
(b) Political:	instability, interventions in domestic markets (for example, subsidies), corruption and lack of civil society;
(c) Technological:	lack of infrastructure, lack of technical standards and institutions for supporting the standards, low technical capabilities of firms and lack of a technology knowledge base;
(d) Economic:	instability, inflation, poor macroeconomic conditions and disturbed and/or non-transparent markets;
(e) Information:	lack of technical and financial information and of a demonstrated track record for many ESTs;
(f) Financial:	lack of investment capital and financing instruments;
(g) Cultural:	consumer preferences and social biases;
(h) General:	intellectual property protection, and unclear arbitration procedures.

The barriers in Table 4 are of a general character. In many cases, though, there will be specific national or local hindrances for the import and deployment of a new technology. Despite the warning in IPCC (2000) that there “is no pre-set answer to enhancing technology transfer” and that therefore the “identification, analysis and prioritization of barriers should be country based”, the analysis to follow is also of a general character⁴⁵.

A short note first on the ‘general’ barriers as identified by the UNFCCC: In Section 2.1.4 intellectual property protection was pointed out as a major barrier to the transfer of technology (Kline et al., 2004). However, poor protection of property rights in a country, including that of intellectual property, may act as a barrier to technology transfer too, as this poses an additional risk to investors or suppliers of technology that may then not be willing to implement a new technology in the country.

⁴⁵ Babu and Michaelowa (2003) and TERI (2005) study barriers specific to the transfer of RETs in India, whereas Nordqvist (2005) provides insight in Chinese conditions for technology transfer.

4.2 Reasons for the CDM to contribute to technology transfer

This chapter goes through the very general reasons for expecting a positive contribution from the CDM in transferring technologies. They have been divided in four:

1. The CDM will stimulate investment, especially in environmentally sound technologies.
2. The CDM institutional structure will mediate between the sender and the recipient party to the technology transfer, thereby facilitating the technology transfer process.
3. As a trade with mutual benefits to both parties, the CDM will increase the efficiency of the technology transfer.
4. The CDM attracts private sector involvement.

The following sections will elaborate on each of these four points in turn.

4.2.1 The CDM will stimulate investment

Given the current stage in global technological development, the potential, all over the world, for mitigating greenhouse gas emissions is tremendous. But it comes at a cost. In developing countries, where the scope and technology options of emission reductions are especially large, the lack of investment capital is usually of corresponding importance (TERI, 2005).

Through the capitalising of the CERs the CDM provides incentives for investment in environmentally sound technologies in developing countries. As EST generally has not been a priority in the developing world, chances are higher that CDM projects will involve technologies that are currently not in use in developing countries. Technology investments are naturally a first condition for technology transfer taking place at all.

To any investor, the decision on whether to invest or not depends on whether a project is perceived as profitable. With the selling of the CERs generated through a CDM project, there is an additional income to the project, one that may just turn it from unprofitable to profitable⁴⁶. Capitalising the CERs thus works as a “financing instrument” and helps overcome financial barriers to technology transfer as identified in Chapter 3.1 (Haake, 2006).

Political and economic instability are also identified as barriers to technology transfer. To any investor, the perceived risk of a project will count against the decision to invest. Uncertainty

⁴⁶ CER-revenues will in many cases need exactly the property of turning profits positive – otherwise (in the absence of other barriers to the project that may be overcome through the CDM) the project would not be considered ‘additional’.

as to the viability and profitability of the project due to political and economic instability may act as a ‘tax’ on investment (Rodrik, 1991), and at worst tip the investment decision to the negative. In this context the revenues from selling the CERs may be seen as a ‘subsidy’ helping to neutralise the negative impact of the uncertainty perceived by investors.⁴⁷

As a further consequence of sparking investment, the CDM is indirectly creating enabling environments for future projects; improving infrastructure, establishing joint ventures and at times also enhancing local capabilities by transferring equipment and knowledge. As such, it can be seen to narrow the ‘technological gap’ and make future projects less ‘alien’ to the environment, thereby reducing the negative impact of technological barriers (Haake, 2006).

The potency of the CDM financing instrument will of course be strongly influenced by the price of the CERs – not to mention that these may be severely diluted by the transaction costs of the CDM bureaucracy (Michelowa and Jotzo, 2005). Babu and Michaelowa (2003) estimated the additional revenue from sales of CERs, given 2003 market prices, to yield an increase in internal rate of return (IRR) in the order of one to five percentage points for different types of renewable energy technology (RET) projects, and concluded that, though small, it could outweigh some risks that may otherwise have prevented investments in RET projects.

Compared to global FDI flows, the projected size of CDM investments is still very small. Nevertheless, it may be an important step towards what Aslam (2002), perhaps somewhat optimistically, saw as “conducting the large global FDI flows on to more carbon friendly trajectories”. Even so, there a big step from investments in new ESTs in developing countries to successful implementation and technology transfer. The next section looks into the CDM’s potential for facilitating this step.

4.2.2 The CDM as mediator and facilitator

As pointed out in Section 1.2.4, the CDM bureaucracy has been criticised as providing disincentives to project developers, due to a costly, complicated and time consuming application process. The administrative structure of the CDM may however be beneficial to technology transfer, in helping to overcome some of the barriers mentioned above. The mediating and facilitating role of the CDM institutions will be the topic of this section.

⁴⁷ However, there is additional risk connected to investment in CDM projects. Flottorp and Kråkenes (2005) summarise the risk components in the CDM process in four categories; certification risk, baseline risk, country risk, and CERs risk.

First of all, the establishing of the DNA in each host country may be a significant step towards reducing institutional barriers. In many developing countries, bureaucratic procedures before a project can be implemented are considered excessive by investors. In the case of CDM projects, the DNA is the only institution in the host country from which the project developers need to seek approval; it may thus significantly reduce the amount of red tape so much feared by investors.

Wilkins (2002) gives examples of cultural and information barriers as thus labelled above, specific to the transfer of technologies from one country to another when not only cultural differences exist but also different requirements of the technology to be put into use⁴⁸. The lack of understanding on the part of foreign suppliers regarding domestic conditions and the requirements and priorities of the technology recipients poses a severe threat to the successful implementation of a new technology, and thereby to the efficiency of the technology transfer. These cultural and information barriers could however be (partly) overcome with the help of the DNA, and through the establishing of the UNFCCC clearing house TT:Clear⁴⁹.

The national CDM criteria, enforced by the DNA, may however in some cases pose a barrier to technology transfer in themselves. According to Nordqvist (2005), Chinese CDM policies, though explicitly emphasising technology transfer, actually limit it by targeting specific technologies and requiring foreign companies to be ‘engaged’.

Another issue is the potential trade-off between technology transfer and sustainable development as pointed out in Haake (2006). As will be discussed in Chapter 4.3, CDM projects involving technology transfer are generally large scale projects involving complex technologies, whereas projects strong in contributing to sustainable development are generally smaller, more locally attuned projects, often with a preference for local technology.

4.2.3 “Trade, not aid”

Together with the private sector involvement to be discussed in the next section, the ‘market character’ of the CDM is probably what most distinguishes it from previous attempts at technology transfer from the developed world. As is usual, this has encouraged a great deal of optimism with some commentators (while it has spurred the critique of others).

⁴⁸ The example in Wilkins is difference in energy service requirements.

⁴⁹ “Inadequate access to reliable, up-to-date information is a major barrier to the effective development and transfer of environmentally sound technologies under the UNFCCC ... [TT:CLEAR] aims to improve both the quality of the information available and access to it.” (UNEP DTIE Homepage)

According to Aslam (2001), the major problem with previous ‘intents’ on technology transfer were that they were part of official development assistance schemes, and therefore “strongly driven and clandestinely biased by ‘export promotion’ doctrines”. Being instead an economic response to a cost savings opportunity for the industrialised countries, and at the same time an opportunity to the developing countries to capitalise a hitherto unvalued commodity (i.e. emission reductions), the CDM is seen to transform the North-South transaction into a trade with mutual benefits to both parties. As such, the developing country is given “significant leverage” in controlling the resource flow, which is seen to ensure that the “most appropriate technologies are transferred through the CDM projects” and thus improve the efficiency of the technology transfer. All along assisting the host country parties in “guarding, as well as furthering, their national sustainable development objectives” (Aslam, 2001).

However, as in Section 4.1.1, the argument hinges on the status of the CER market.

According to TERI (2005), the CDM market in its early stages was a “buyers’ market”. If the competition for CDM investments is high among host countries, the empowerment envisaged in Aslam (2001) may fail to materialise.

4.2.4 Involvement of the private sector.

Lastly, several authors have pointed to the benefits of the CDM potential for involving the private sector, as Article 12 of the Protocol states that participation under the CDM may involve “private and/or public entities” and national emission commitments are expected, at least to some extent, to be handed down to private entities in the Annex I countries.

In a similar fashion to the argument in Section 4.1.3, this is generally seen to trigger efficiency of the technology transfer compared to public investment programmes (Wilkins, 2002; Babu and Michaelowa, 2003).

“The CDM has great potential to create partnerships between the private sector in industrialised countries and between governments and the private sector in developing countries, which could facilitate the transfer of renewable energy technology.” (Wilkins, 2002; 51-52)

As technology is generally owned by companies rather than governments, the involvement of companies will be crucial to successful technology transfer. The CDM stands out compared to government led technology transfer programmes as it provides *incentives* to investors rather than expecting private companies to ‘share’ intellectual property. (Forsyth, 1998; Aslam, 2001; Wilkins, 2002)

4.3 Empirical results on technology transfer under the CDM

The purpose of this section is to give a summary of the results found in the three quantitative studies of technology transfer under the CDM (referred to in Chapter 2.2). As to the interpretation of these results, there are several problems: Firstly, as none of the studies employs a definition of technology transfer equal to the one established in Part 3, the results do not ‘hold true’ according to this definition. Secondly, as the studies all employ different definitions of technology transfer, their results are not directly comparable to each other either.

Furthermore, their choices of datasets differ in important respects; whereas Haites et al. (2006) investigates all proposed CDM projects for which public comments had been solicited prior to a given date (20 June 2006), Haake (2006) and TERI (2006) limit the investigation to all *registered* projects (as of 1 January and 1 May 2006 respectively). The number of projects in Haites et al.’s study is 854, while that of TERI is 171 and that of Haake 63. Also, TERI as well as Haites et al. are not able to decide on whether technology transfer occurred in almost half of the cases, while this number is less than 5% under the strictest definition (tier three, dependent view⁵⁰) in Haake (2006).

For these reasons, the respective findings of the three studies on the degree of technology transfer among CDM projects – 33.5% (Haites et al.), 30% (TERI) and 25% (Haake) – ought at best to be interpreted qualitatively; there *are* signs of technology transfer under the CDM.

This is not to dismiss the findings of the studies just mentioned. Exact findings on technology transfer rates are not emphasised by any of the authors. Rather, they pay a lot of attention to the variation in instances of technology transfer for different subgroups of the dataset, such as project type and host country and according to project size. These results will be related and discussed in the following sections.

4.3.1 Technology transfer according to project size

Throughout, in both Haites et al. (2006) and Haake (2006), technology transfer is more common for larger projects⁵¹. In Haites et al., one-third of all CDM projects involve technology transfer, but they account for 66% of the annual emission reductions. Dividing the projects into different categories, according to type of technology, host country, small- vs.

⁵⁰ When the subsequent tiers in the definitions in Haake (2006) presuppose the criteria of previous tiers, this is called the ‘dependent view’.

⁵¹ TERI does not take the size of projects into account.

large-scale, unilateral vs. projects with foreign participants, the result remains that technology transfer claims are more common for larger projects⁵². (Haites et al., 2006)

Large projects – mainly in sectors such as HFC and N₂O destruction – do generally involve more complex technologies, technologies that to a larger extent will have to be imported from developed countries. New and foreign technologies do also mean a larger investment. For bigger projects the costs of importing new technologies (also due to import barriers that exist in many developing countries) will matter relatively less compared to CER-revenues.

Interestingly, when breaking the results in Haites et al. (2006) up according to different kinds of technology transfer claims, the otherwise persistent result of larger projects claiming more technology transfer does not hold. While equipment transfer is more common for larger projects, projects involving transfers of both equipment and knowledge or knowledge alone are generally smaller (Haites, 2006)⁵³.

4.3.2 Technology transfer for different project types and technologies

In both Haake (2006) and Haites et al. (2006), the renewable energies sectors wind and hydropower have a low rate of technology transfer compared to HFC- and N₂O-destruction projects. The main reason for this is that these technologies already were in use as they ‘had a use’ also prior to the CDM: providing electricity. No such use existed for the HFC and N₂O handling technologies prior to the CDM. In addition these technologies are generally more complex than renewable energy technologies (Haake, 2006).

The fact that these technologies have already been in use for a while could also constitute a disadvantage with respect to import tariffs. If a developing country already has developed an industry based on a particular technology, it may want to protect this sector through the use of import barriers. For instance in China, import tariffs on renewable energy technologies are considered an important barrier to the transfer of such technologies.

There is thus a potential trade-off, pointed out by Haake (2006), between projects that contribute to the sustainable development of the host countries, such as small-scale, locally

⁵² Except for fugitive emission reduction and coal mine/bed methane projects, where the projects claiming technology transfer are much smaller than the category average.

⁵³ About one-third of the projects that claim technology transfer involve only equipment, but those projects account for almost two-thirds of the emission reductions. Almost half of the projects that involve technology transfer claim both equipment and knowledge transfers, but they account for only about one-quarter of the emission reductions. Transfers of knowledge alone involve 16% of the projects accounting for 8% of the emission reductions. (Haites et al., 2006)

based projects – typically renewable energy projects – and projects involving a large amount of technology transfer.

4.3.3 Technology transfer for different countries

Host countries:

The rate of technology transfer varies significantly across host countries. As regression results in Haites et al. (2006) do not indicate a link between technology transfer rate and host country size or per capita GDP, other host country characteristics would have to explain the distribution. Obvious factors are national import policies, technological development in given sectors, host country natural endowments and industrial outlook, together with national CDM policies. These all influence distribution of CDM projects across different sectors and the scope for technology transfer within a given sector. Also, some countries generally have much larger projects than the average, as in the case of China, which may also explain a higher share of technology transfer claims⁵⁴.

The one country that stands out in all three studies with a strikingly low technology transfer rate is India. India is also the country hosting the highest number of CDM projects. The explanations offered in Haake (2006) are, firstly, that India has quite high import tariffs on foreign products. Together with the fact that India has “a competitive market for any product”, this makes it difficult for a European company to implement technology at a competitive price. As legal protection is not very strong and commercial transaction procedures are seen to be unsure, this poses a further hindrance to investors (Haake, 2006).

Secondly, India is held by the IEA to be the market leader for bio energy⁵⁵ technology together with China. India is also among the smaller technology market leaders in hydropower⁵⁶ (Haake, 2006). In the UNEP Risø CDM pipeline (Fenhann, 2007), half of all registered Indian projects are in hydropower, biogas and biomass – sectors in which Indian domestic competence “precludes ITT” (TERI, 2006).

In all three studies, projects involving landfill gas seem to have a high propensity to involve technology transfer. As of April 1 2007, there was still only one project involving landfill gas

⁵⁴ In the case of China, national policies are actually considered a barrier to technology transfer (Nordqvist, 2005). But China nevertheless hosts unusually large CDM projects, which are generally more prone to technology transfer.

⁵⁵ Bio energy includes biomass as well as biogas.

⁵⁶ Around 12% of India’s electricity is generated through hydropower (Haake, 2006).

management in India, whereas 29 such projects (67%) have been registered in South and Central America⁵⁷.

Investor countries:

The obvious expectation that technology transfer be more common for projects involving foreign participants is confirmed in Haites et al. (2006). This is also partly explained by the fact that these projects tend to be larger than average. According to Haake (2006), France, Spain and the Netherlands – specialised in the transfer of hydropower, wind energy and landfill gas technology – are the largest exporters of technologies through the CDM.

4.3.4 Summing up

In all three studies, technology transfer seems to be more common for larger projects. As larger projects are generally more profitable, they do also have larger scope for investment in new technology. Technology transfer is also more common in projects where the greenhouse gas reduction is an end in itself, as with HFC and N₂O destruction projects; an end not likely to be given much priority in developing countries prior to the CDM. Depending on the state of technological development of the host country, renewable energy and energy efficiency projects may also involve some technology transfer, but less so the more advanced the host country.

⁵⁷ Where they are often “first-of-kind” (TERI).

Part 5: Six Indian cases

Six CDM projects were chosen to be studied for instances of technology transfer. The original objective of the analysis was twofold:

- Firstly, as a first step towards a quantitative analysis of technology transfer: To what degree did technology transfer take place in these six projects? Cases were chosen that all at first glance seemed promising with respect to technology transfer. Would they still do so upon further scrutiny?
- Secondly: Does the definition of technology transfer developed Part 3 allow us to decide on the occurrence of technology transfer when put into practice? Are the operational criteria working; are we able to settle whether they are satisfied with reasonable certainty?

To both of these tasks, comprehensive and reliable information on the technology to be used in the project is needed. The information provided in the Project Design Documents is however expected to be both incomplete and incorrect. The main purpose of the PDD is to convince the DOE of the additionality of the project and its baseline calculations – not of the degree of technology transfer involved. Whereas one could expect the information concerning the first two issues to be reliable in the PDD of a project that has been validated, information on technology transfer is not to be trusted in the same way.

Furthermore, although the guidelines to completing the PDD state that section “A.4.3. Technology to be employed by the project activity” is to include a description of “how environmentally safe and sound technology and know-how to be used is transferred to the host Party(ies)”, this information is often not even provided. This is evident from the results of Haites et al.: In 40% of all *registered* projects there was no mention of technology transfer. As registration is subsequent to validation by the DOE, this is a clear sign that technology transfer does not have priority with the DOEs – and one could therefore not expect the information on technology transfer in the PDDs to have been verified by an independent party.

For these reasons, the case study was intended to rely on additional information on the six CDM projects. The projects were thus to be chosen based on two selection criteria: The projects chosen ought to seem *likely* to involve some degree of technology transfer, at least

superficially, and they ought to be chosen on the basis of the availability of additional information.

It turned to be more difficult to obtain extra information on CDM projects than expected. Six projects were therefore chosen in accordance with the former criterion only. Additional information was to be obtained subsequently, through phone interviews with the project developers⁵⁸. As the projects were already registered and were being carried out, there would at least not be in the obvious interest of project developers to misinform, and they could be asked necessary questions that were not given an answer in the PDD.

The six projects are of three types: Two projects are wind energy projects (renewable energy), two projects involve thermal oxidation of HFC 23 (fugitive emissions), and two projects involve the utilisation of waste gas for generating power (energy efficiency). All projects displayed clear potential for an instance of technology transfer.

Project developers are requested to put down contact information on all participants in the project activity in Annex 1 of the PDD (UNFCCC, 2005). However, contact persons were successfully reached in only two cases. They both asked to be contacted by e-mail. A list of questions was then e-mailed to each project developer.

As one week later only one answer was obtained, the case ‘analysis’ to follow is almost entirely based on the information written in the PDDs – in spite of the abovementioned objections to this approach. Especially regarding general information on the relevant sector, more information could easily have been obtained. But there simply wasn’t time. For this reason, the analysis is merely to be considered tentative relative to both of its original objectives: Firstly, we’re assessing whether technology transfer as it has been defined in this thesis occurred in the six projects, *according to the PDD*. Secondly, we get an indication through the PDDs of what information is available on issues related to deciding on technology transfer, and whether this information enables us to check whether the selected technology transfer criteria of Part 3 are satisfied.

5.1 Description of the projects

Below follows a short description of the salient features of each project, together with a quick assessment with respect to the four criteria of the definition of Part 3. In the beginning of each

⁵⁸ Given the blurry character of the information provided in several of the PDDs, a phone interview seemed much more preferable than sending questions by e-mail.

section is a summary of background information provided in the PDDs on the sector in question.

5.1.1 Two wind power projects

Relevant background information provided in the PDDs: The “State Grid penetration” of wind power in the Indian states is as follows:

Andhra Pradesh 1.2%,

Gujarat 1.9%,

Karnataka 1.0%,

Maharashtra 1.6%,

Rajasthan 0.3%,

Tamil Nadu 9.5%.

Tamil Nadu is thus by far the leader, having achieved over 9% penetration, whereas the penetration level of wind farms in Karnataka is merely 1%.

Wind I: 12 MW Bundled Wind Power Project in Tenkasi, Tamilnadu⁵⁹

Company in India: NEG Micon (I) Private Limited

Where: Tenkasi in Tamil Nadu

What has been done: 16 Wind Electric Generators (WEGs) have been installed to generate electricity from wind that is sold to the state electricity grid. As the power sector in Tamil Nadu is highly coal dominated, the electricity generated in this project displaces electricity that would otherwise have been generated from coal.

Features of the technology: Each WEG (the ‘NM 48/750 kW’) has a “rated output” of 750 kW and is said to be “one of the machines well known for its best performance”. The technical design of the WEGs comes from NEG Micon A/S in Denmark⁶⁰. According to the PDD, NEG Micon (I) Private Limited has set up manufacturing plants in Chennai and Pondicherry where the WEGs are being manufactured, however with over 60% of the components imported.

⁵⁹ The PDD can be found at <http://cdm.unfccc.int/Projects/DB/DNV-CUK1165487562.94/view.html>

⁶⁰ The machine is type tested and certified by DNV, Denmark A/S.

Operation and maintenance: NEG Micon (I) Private Limited signs an Operations and Maintenance Agreement with the project promoter. NEG Micon (I) Private Ltd also has adequate and technically qualified site managers to ensure constant monitoring of wind turbines installed. In addition, NEG Micon (I) Private Ltd has prepared a ‘CDM Manual’ that will facilitate easy monitoring of the project activity. Most of the farmers that sold their land to the project have allegedly been provided with employment opportunities – some of them are for instance working as watchmen in the wind farm site. Also “young people with the minimum qualification have been trained and absorbed as operators for the turbines”.

Technology transfer:

Based on the information provided above, indicators of technology transfer have been found in the following categories:

Origin	Novelty	Improvement	Capacity
Yes!	?	?	Some

Wind II: Bundled wind power project in Chitradurga, Karnataka⁶¹

Company in India: Enercon (India) Ltd (EIL)

Where: Chitradurga, Karnataka

Project activity: 28 “wind energy converters” (WECs) with an aggregate capacity of 16.8 MW have been installed to generate electricity that is sold to the state grid. The project activity includes development, design, engineering, procurement, finance, construction, operation and maintenance of wind energy based electric generating stations supplying electricity to the grid.

Features of the technology: Each machine has a capacity of 600kW. The WECs proposed to be used are specifically designed for the wind regimes prevalent in India. EIL has secured and facilitated the technology transfer for wind based renewable energy generation from Enercon GmbH, has established a manufacturing plant at Daman in India, where along with other components the "Synchronous Generators" using "Vacuum Impregnation" technology are manufactured. Moreover, Enercon India Limited has acquired capabilities to export

⁶¹ The PDD can be found at <http://cdm.unfccc.int/Projects/DB/DNV-CUK1140782658.34/view.html>

synchronous generators and blades of the wind turbines, is recognized as an export house by the Government of India and has successfully exported wind turbines to Australia.

Operation and maintenance: EIL is the turbine supplier and is also the operations and maintenance contractor. EIL is also the exclusive O&M contractor to the wind projects in the wind farms developed by it.⁶² The project is expected to directly create an annual employment opportunity for 30-35 persons during the operation stage

Technology transfer:

Based on the information provided above, indicators of technology transfer have been found in the following categories:

Origin	Novelty	Improvement	Capacity
Yes?	?	?	Yes

5.1.2 Two HFC oxidation projects

Relevant background information provided: There are no regulations (national, state or local government) requiring the total destruction of HFC 23, so HFC 23 has historically been emitted to the atmosphere as there is a very limited market (thought to be less than 2 tonnes per annum) for HFC 23 in India.

Although it has low toxicity, the GWP of HFC 23 is 12 000. Under the Montreal Protocol the HCFC 22 production level for non-feedstock use will be frozen at 2015 levels from 2016 and is expected to fall to zero by 2040, so HCFC 22 can in principle be produced, and HFC 23 will be generated as its waste gas, until the year 2040 in the absence of CDM projects. As feedstock uses of HCFC 22 are not controlled under the Montreal Protocol, application of HCFC 22 for feedstock uses may continue even beyond 2040.

According to the PDD of HFC I, there were three companies going for this kind of projects in India at the time of application; in addition to the two below, GFL is in the process of a CDM project.

⁶² The investors in the wind farm are private/public sector firms who are generally passive financial investors who own small capacities in a wind farm.

HFC I: GHG emission reduction by thermal oxidation of HFC 23 at Navin Fluorine International Limited (NFIL), Surat, Gujarat, India⁶³.

Company in India: Navin Fluorine International Limited (NFIL)

Where: Surat, Gujarat, India

Project activity: The project activity will capture and destroy HFC 23 that is currently emitted to atmosphere during the production of HCFC 22. Without the project activity HFC 23 would continue to be emitted to atmosphere. NFIL will lead the Project Activity to install a system to capture, store and destroy HFC 23 by thermal oxidation, and provide for a treatment system to convert the acidic waste gases from thermal oxidation into harmless salts. NFIL will install storage capacity to store HFC 23 until the thermal oxidiser is commissioned, and also for periods when the thermal oxidiser is offline. The thermal oxidiser system will decompose “more than 99.999%” of the HFC 23, reducing the discharge of HFC 23 to the atmosphere to a level close to zero.

Features of the technology: NFIL will install a thermal oxidiser system of UK design, incorporating a Japanese designed and supplied thermal oxidiser unit. INEOS Fluor Limited, UK (IFL) will be the technical sponsor for this project activity. This decomposition method for HFC 23 has been proved in the UK since 1999 to be a reliable efficient method to decompose HFC23 from HCFC 22 production.

Operation and maintenance: IFL in the UK will be providing technical support at each stage of the project activity. Details of the operation are to be described in operating procedures and these procedures will be used as the basis for the appropriate training of the operational staff of this project facility. Select NFIL staff will undergo specialised training from the technical experts from IFL and the Thermal Oxidiser supplier, who will also depute their experts at the NFIL site for project commissioning and training of personnel.

Technology transfer:

Based on the information provided above, indicators of technology transfer have been found in the following categories:

Origin	Novelty	Improvement	Capacity
Yes!	Yes	Yes	Yes!

⁶³ The PDD can be found at <http://cdm.unfccc.int/Projects/DB/DNV-CUK1167824240.14/view.html>

HFC II: GHG emission reduction by thermal oxidation of HFC 23 at refrigerant (HCFC-22) manufacturing facility of SRF Ltd.⁶⁴

Company in India: SRF Ltd.

Where: Rajasthan

Project activity: The ‘Project Activity’ includes identification, design, engineering, procurement, finance, construction, operation and maintenance of a system for collection, storage and thermal oxidation of HFC 23. SRF has undertaken storage and thermal oxidation of HFC 23 since April 2004. Based on the guarantees offered by the process licensors and plant suppliers, more than 99.99% of feed HFC 23 is destroyed.

Features of the technology: SRF is importing the thermal oxidation equipment and technology from M/s SGL Acotec GmbH Germany. Thermal oxidation facility has been commissioned in end August 2005.

Specifications: The technology is a proven one and plants with similar technology are operating in Germany. The decomposition plant will be very reliable and capable of delivering complete destruction of HFC 23. Necessary safety features are built into the process design.

Operation and maintenance: Around 15-20 persons direct and indirect employment will be created by this project.

Technology transfer:

Based on the information provided above, indicators of technology transfer have been found in the following categories:

Origin	Novelty	Improvement	Capacity
Yes!	Yes	Yes	Probably

5.1.3 Two waste gas utilisation (WGU) projects

Relevant background information provided from the PDDs of the two projects: Waste gas utilisation is not mandated under Indian legislation. Furthermore there are no legal

⁶⁴ The PDD can be found at <http://cdm.unfccc.int/Projects/DB/DNV-CUK1129901204.48/view.html>

requirements on the choice of a particular technology for power generation, nor do environmental regulations restrict the choice of fuel for generation units located anywhere in India. During the last five years (allegedly catalysed by expectation of CDM revenue), waste gas recovery for power generation has been on a rise in India. However, the power generation from Corex waste gas has never been done in India before.

The two projects are carried out by two companies that are separate legal entities, however, the second project (WGU I) will get the waste gas from the company involved in the first project (WGU II).

WGU I: Generation of Electricity through combustion of waste gases from Blast furnace and Corex units at JSW Steel Limited (in JPL unit 1), at Torangallu in Karnataka, India⁶⁵

Company in India: JSW Steel Ltd.

Where: Torangallu in Karnataka, India

Project activity: The company will use waste gas from its blast furnace⁶⁶ and its Corex units⁶⁷ to generate power to be used in the steel production process, instead of flaring it without use. The power generated will allegedly substitute the major quantity of electricity needed in production, which would otherwise have been generated by a separate power producer using coal.

Features of the technology: The PDD does not state the origin of the technology. To this end they install a special steam generator that can utilise the different calorific values of the two kinds of waste gases to get a stable flame without using any conventional fuel⁶⁸, and that also takes into account the explosive and toxic nature of these waste gases. According to the PDD, this technology is the first of its kind in the world which addresses the problems involved in combined firing of gases differing in calorific value, and that generates power from a mixture of blast furnace and Corex waste gases.

Operation and maintenance: The operation and maintenance of waste gas recovery for power generation (especially the aspects related to flame stability, and safety) is not well known and the skilled personnel are not available in the host country. Due to this, the

⁶⁵ The PDD can be found at <http://cdm.unfccc.int/Projects/DB/SGS-UKL1142515628.74/view.html>

⁶⁶ A blast furnace is a metallurgical furnace used for smelting to produce metals, generally iron (Wikipedia.).

⁶⁷ The Corex process is a process to produce liquid raw iron. Contrary to the blast furnace no blast furnace coke is used, but normal coal, ore or Pellets (Wikipedia).

⁶⁸ Boiler firing system consists of separate elevations for BF and Corex waste gases and start-up fuel (LFO). By combining Corex with higher calorific value and BF gases with lower calorific value, the flame stability is achieved without any conventional fuel support. The novel boiler design, come-up first time in the world, applied in this project achieves the required steam temperature with widely varying calorific value of gases.

personnel of the proponent of the project activity had to be trained to operate such waste gas recovery system. Due to the novel and complex nature of the design, the contractor for design, supply and erection was required to seek back up support from Alstom Power Inc., USA. “A training session was conducted for the employees”.

Technology transfer:

Based on the information provided above, indicators of technology transfer have been found in the following categories:

Origin	Novelty	Improvement	Capacity
?	Yes!?	Yes	Yes!

WGU II: Use of waste gas use for electricity generation at JSW Energy Limited⁶⁹

Company in India: JSW Energy

Where: Torangallu in Karnataka, India

Project activity: The project involves putting in place systems and infrastructure for generation of electricity using Corex gas and other waste gases that would otherwise being flared off in JSW Steel Limited. The electricity generated is supplied to JSW Steel Limited and the state grid⁷⁰. The draft National Electricity Policy (revised in August 2004) asserts ‘coal would necessarily continue to remain the major fuel’ in the absence of this project.

Features of the technology: The PDD does not state the origin of the technology. The project activity involved additional investments to the tune of INR 240 Million (to the investment in power generation using coal) to achieve a steady supply of the waste gas. The project activity (stabilization of corex gas and other waste gases and use of these for power generation) is the first of its kind in the world (“only anecdotal evidence is available”). In any case, no project activity of this type (using either purely gas, any combination with other waste gas or fuels) was operational in India at the time of the start of the project activity.

Operation and maintenance: Skilled and/or properly trained workmen to operate and maintain the gas holder and maintaining the steady supply of the waste gas and operation of

⁶⁹ The PDD can be found at <http://cdm.unfccc.int/Projects/DB/SGS-UKL1143807645.33/view.html>

⁷⁰ Karnataka Power Transmission Corporation Limited (KPTCL)

waste gas based power plant were not available. Also additional safety measures (in the form of personnel training and Personnel Protective Equipments) were required. A training session was conducted for the employees. Around 5 people are additionally employed after the project activity in the plant and 20 people were temporarily employed during construction.

Technology transfer:

Based on the information provided above, indicators of technology transfer have been found in the following categories:

Origin	Novelty	Improvement	Capacity
?	Yes!	Yes	Yes!

5.2 Conclusion of the case analysis.

5.2.1 Summary of results

The findings on technology transfer indicators in the six cases are summarised in Table 7.

Case:	Criterion:			
	Origin	Novelty	Improvement	Capacity
Wind I	Yes!	? a) c)	? a) b)	Some!
Wind II	Yes?	? a) c)	? a) b)	Yes
HFC I	Yes!	Yes d)	Yes e)	Yes!
HFC II	Yes!	Yes d)	Yes e)	Probably
WGU I	?	Yes!?	Yes e)	Yes!
WGU II	?	Yes!	Yes e)	Yes!

Table 5: Findings on technology transfer in the six Indian cases

- Not much is said of novelty, nor on the difference from other existing technologies.
- There is some information on the quality of the technology, but not enough to assess with respect to 'Improvement'.
- Allegedly it is "not common practice", which is not the same as being new.
- Most probably no projects before the CDM applied this technology, as there was no reason to, but there may however be other CDM projects using the same technology now.

- e) This follows for the same reason as for the technology being new. As no one has done this in India before, this is an improvement to existing technologies.

5.2.2 Implications for the specification of technology transfer indicators

What does the case analysis allow us to say as to the purposefulness of the indicators that were chosen in Chapter 3.2? The indicators were chosen in accordance with three ‘quality criteria’⁷¹:

- i) Relevance: Is the indicator truly an indicator for the criterion in question?
- ii) Clarity: Does the indicator allow one to decide dichotomously whether the criterion is satisfied or not?
- iii) Information: Does the indicator allow one to decide whether the criterion is satisfied or not given the available information?

In principle, compliance of the indicators with all three criteria could be evaluated on the basis of the case analysis, although the main discussion as to the first quality criterion was provided in Chapter 3.2. The question marks in Table 7 could be a warning that the second quality criterion, ‘information’, is not satisfied. However, given the limited information that was obtained for the six cases – and considering that all technology transfer criteria categories had decisive indicators in at least half of the cases – the technology transfer indicators seem to satisfy the information criterion.

As to the clarity of the indicators, there may be a problem with the indicator for capacity, as becomes clear in Wind I. As the transfer of capacity is more *gradual* than the other criteria, this is hardly surprising. Probably the indicators chosen for this category ought to be more complex. Suggestions for indicators qualifying for ‘capacity-strength’ were offered in Section 3.2.4. One solution to the problem could be to combine the ‘score’ of the project along several such qualifiers and then specify a minimum level above which the criterion is satisfied.

⁷¹ This term is merely chosen to distinguish the criteria for the selection of indicators from the criteria of the definition of technology transfer.

Part 6: Conclusion

This thesis has established an operational definition of technology transfer that is suitable for empirical investigation of the occurrence of technology transfer in projects under the Kyoto Protocol's Clean Development Mechanism. In doing so, several issues were taken into account, concerning both the CDM and technology transfer.

The literature on technology transfer shows the concept to be both vague and multifarious. Definitions vary from the mere change-of-hands of technical equipment to comprehensive processes of enabling environments and capacity building. Political texts take a comprehensive view on technology transfer (at times close to diluting its meaning), whereas political practice usually narrows it down to something that does not take neither the special nature of technology nor the meaning of 'transfer' properly into account.

To the backdrop of the CDM and the Climate Convention, the economic literature on technology transfer was reviewed with the hope of finding a more stringent method for assessing technology transfer. Although frequently employing the term 'transfer', it turns out that this literature is mainly concerned with technology *diffusion* and technology *spillovers*. Also, economics seems to have been more concerned with measuring the *effects* of technological diffusion and spillovers ('output approach') than with stating necessary conditions for their occurrence ('input approach').

When making a definition to be used in empirical testing, one must seek the balance between, on the one hand, capturing all the relevant features, and, on the other, making the definition operational. Striking this balance for a definition of technology transfer in relation to the CDM is the main achievement of this thesis.

The occurrence under the CDM of technology transfer as it has been defined in this thesis has not yet been subject to quantitative studies. The hope is that this may still happen as a part of a larger study that is presently conducted by TERI on the impact of CDM on investments in new technology.

The study of six Indian cases provided in this thesis, together with the review of other studies of technology transfer under the CDM, do however give a clear indication that the CDM has a potential for transferring technology.

Even so, the findings of this thesis do not by any means indicate a high likeliness for a CDM project in bringing about technology transfer. Rather on the contrary; in some sectors and

some countries, the incidence of technology transfer seems strikingly low. And the more comprehensive the definition of technology transfer applied, the lower is its incidence.

This points to a problem insofar as technology transfer is deeply needed and the CDM has so far been among very few instruments identified for achieving it. In spite, thus, of the CDM's potential – for financing investment in ESTs, for facilitating the transfer process, for increasing the efficiency of the technology transfer by leveraging potential technology receivers and involving private companies, the principal owners of technology, on their own terms – technology transfer does not yet seem to have lifted off.

So, what should be done? On the basis of the findings of this thesis – what ought to be done?

Considering the problems at hand – technology transfer moving too slow while climate change is moving too fast – improvement of analytical tools may seem a strange priority. This thesis has defined technology transfer and prepared the ground for assessing it; it has not investigated how to make it happen.

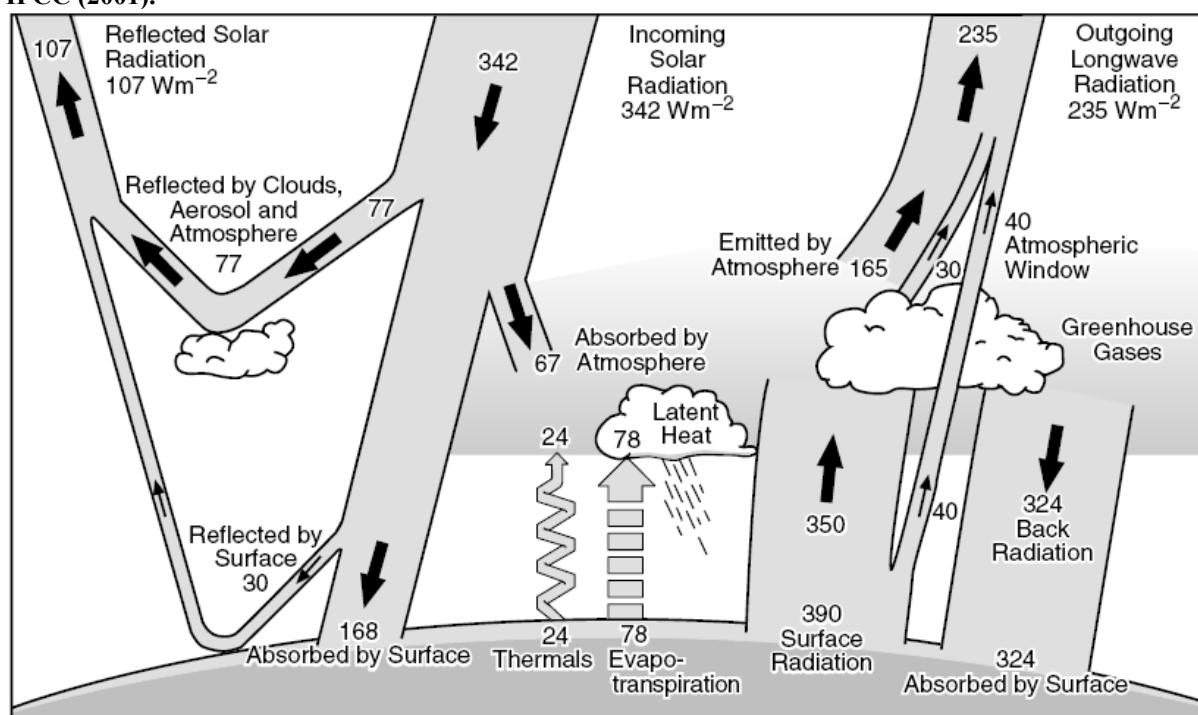
There is however one clear 'policy implication' from what has been discussed in the previous chapters: It should not be left to CDM project developers to define technology transfer when reporting whether it takes place in their project. Existing opinions and definitions differ too widely. At the general level, official CDM guidelines for completing the PDD need to specify what they mean by 'technology transfer'. At the national level, host countries that want to include technology transfer among their CDM requirements ought to provide a definition of technology transfer based on a thorough analysis of i) what they want when urging technology transfer and ii) how they can verify a project's contribution to technology transfer.

Evidently, these definitions would in all likelihood be different from the definition arrived at in this thesis. They would to a larger degree reflect politics; *needs* and *interests*. This would not necessarily be a bad thing.

Appendix

The greenhouse effect

Figure A- 1: The Earth's annual and global mean energy balance. Of the incoming solar radiation, 49% (168 Wm^{-2}) is absorbed by the surface. That heat is returned to the atmosphere as sensible heat, as evapotranspiration (latent heat) and as thermal infrared radiation. Most of this radiation is absorbed by the atmosphere, which in turn emits radiation both up and down. The radiation lost to space comes from cloud tops and atmospheric regions much colder than the surface. This causes a greenhouse effect. Source: IPCC (2001).



Registered projects in the UNEP Risø CDM pipeline (Fenhann, 2007).

Project distribution according to host country:

The first two columns give the distribution of number of projects, the third column gives the distribution of the average number of CERs issued yearly. The last column shows the ratio of the share in total CERs to be issued yearly to the share in numbers of projects.

Table A- 1: Registered projects by April 1 2007 according to host country.

Host country	Registered projects		CERs issued yearly	Ratio of relative share of CERs to relative share of projects
	Frequency	Percentage	Percentage	
Argentina	7	1.19	2.55	2.14
Armenia	2	0.34	0.13	0.38
Bangladesh	2	0.34	0.22	0.65
Bhutan	1	0.17	0	0

Bolivia	1	0.17	0.07	0.39
Brazil	95	16.1	12.09	0.75
Cambodia	1	0.17	0.04	0.24
Chile	16	2.71	2.39	0.88
China	52	8.81	40.42	4.59
Colombia	6	1.02	0.33	0.33
Costa Rica	4	0.68	0.17	0.25
Cyprus	2	0.34	0.06	0.17
Dominican Republic	1	0.17	0.10	0.58
Ecuador	9	1.53	0.34	0.22
Egypt	2	0.34	1.15	3.37
El Salvador	2	0.34	0.29	0.85
Fiji	1	0.17	0.02	0.12
Guatemala	5	0.85	0.22	0.26
Honduras	10	1.69	0.16	0.10
India	204	34.58	16.52	0.48
Indonesia	8	1.36	1.24	0.91
Israel	5	0.85	0.19	0.23
Jamaica	1	0.17	0.04	0.25
Malaysia	14	2.37	1.36	0.57
Mexico	78	13.22	4.76	0.36
Moldova	3	0.51	0.04	0.07
Mongolia	3	0.51	0.20	0.40
Morocco	3	0.51	0.18	0.35
Nepal	2	0.34	0.07	0.22
Nicaragua	3	0.51	0.36	0.71
Nigeria	1	0.17	1.19	7.02
Pakistan	1	0.17	0.84	4.93
Panama	5	0.85	0.09	0.11
Papua New Guinea	1	0.17	0.22	1.31
Peru	4	0.68	0.40	0.58
Philippines	8	1.36	0.20	0.15
South Africa	6	1.02	0.22	0.22
South Korea	12	2.03	9.91	4.88
Sri Lanka	4	0.68	0.09	0.14
Tunisia	2	0.34	0.55	1.61

Uganda	1	0.17	0.03	0.17
Vietnam	2	0.34	0.54	1.60
Total	590	100	100	1.00

Project distribution according to sector:

The first two columns give the distribution of number of projects, the third column gives the distribution of the average number of CERs issued yearly. The last column shows the average size of all projects in the sector

Table A- 2: Registered projects according to project type.

	No of projects		CERs issued yearly	Average number of CERs issued yearly per project
Type of project	Frequency	Percentage	Percentage	
Agriculture	78	13.22	3.40	54 641
Biogas	40	6.78	0.66	20 802
Biomass energy	133	22.54	6.10	57 458
Cement	14	2.37	1.61	143 866
Coal bed/mine methane	2	0.34	0.34	211 251
EE households	3	0.51	0.03	14 119
EE industry	57	9.66	5.07	111 487
EE service	2	0.34	0.01	7 277
EE supply side	7	1.19	0.19	33 161
Fossil fuel switch	13	2.20	0.37	35 649
Fugitive	3	0.51	1.91	798 124
Geothermal	5	0.85	1.17	292 660
HFCs	13	2.20	46.86	4 519 047
Hydro	98	16.61	3.64	46 553
Landfill gas	43	7.29	9.16	266 977
N ₂ O	5	0.85	14.75	3 699 300
Reforestation	1	0.17	0.02	25 795
Solar	4	0.68	0.03	10 816
Tidal	1	0.17	0.25	315 440
Transport	1	0.17	0.20	246 563
Wind	67	11.36	4.23	79 175

Total	590	100	100	212 474
-------	-----	-----	-----	---------

List of abbreviations

AAU - assigned amount units

CDM - The clean development mechanism

CER - certified emission reductions

CH₄ - methane

CO₂ - carbon dioxide

CO₂e - CO₂-equivalent

COP - Conference of Parties

DNA - Designated National Authority

DOE - Designated Operational Entity

EB - CDM Executive Board

EE - energy efficiency

EIT - Economy in transition

ERU - emission reduction units

EST - Environmentally Sound Technology

ET - The emissions trading scheme

EU - European Union

EU ETS - EU emission trading scheme

FDI - Foreign Direct Investment

GHG - greenhouse gas

GNA - Green National Accounting

GWP - Global Warming Potential

H₂O - water vapour

HFCs - hydrofluorocarbons

IPCC - The Intergovernmental Panel on Climate Change

JI - The joint implementation mechanism

LULUCF - land use, land-use change and forestry

N₂O - nitrous oxide

NGO - Non-governmental organisation

PDD - Project Design Document

PFCs - perfluorocarbons

R&D - Research and developmet

RET - renewable energy technology

RMU - removal units

SD - sustainable development

SF₆ - sulphur hexafluoride

TERI - The Energy and Resource Institute

TFP - total factor productivity

UNDP - United Nations Development Programme

UNEP - United Nations Environmental Programme

UNFCCC - The United Nations Framework Convention on Climate Change

WEC - wind energy converter

WEG - Wind Electric Generator

WGU - waste gas utilisation

References/Literature

Aslam, M.A. (2001): “Technology transfer under the CDM. Materializing the myth in the Japanese context?”, *Climate Policy* No. 1, 451–464

Babu, N.Y.D. and A. Michaelowa (2003): “Removing Barriers for Renewable Energy CDM Projects in India and Building Capacity at the State Level”, HWWA-Report 237, Hamburg Institute of International Economics.

Black, J. (2003): *Oxford Dictionary of Economics* (2nd ed.). Oxford University Press, Oxford and New York.

Branstetter, L. (1996): “Are knowledge spillovers international or intranational in scope? Microeconomic evidence from the U.S. and Japan”, NBER Working Paper 5800.

CDM India – http://cdmindia.nic.in/index_full.htm

CDM Watch (2003): *The Clean Development Mechanism (CDM) Toolkit - A resource for stakeholders, activists and NGOs*. CDM Watch.

Cincera, M. and B. van Pottelsberghe de la Potterie (2001): “International R&D Spillovers: a survey”, *Cahiers Economiques de Bruxelles* 169 No. 1

de Coninck, H.C., F. Haake and N.H. van der Linden (2007): “Technology transfer in the Clean Development Mechanism”, ECN-E--07-009, Energy research Centre of the Netherlands.

Di Maria, Corrado and Edwin van der Werf (2006): “Carbon Leakage Revisited: Unilateral Climate Policy with Directed Technical Change”, *Nota di Lavoro* 94.2006, Fondazione Eni Enrico Mattei.

DNA of Indonesia Homepage: <http://dna-cdm.menlh.go.id>

Fenhann, J. (2007): *The CDM Pipeline*, UNEP Risø Centre, April 1 2007.

Flottorp, L.S and A.J. Kråkenes (2005): *Clean and Clear – Is the CDM Attractive for Investors in Emerging Markets?* Master Thesis, Norwegian University of Life Sciences.

Forsyth (1998): “Technology transfer and the climate change debate”, *Environment: Science and Policy for Sustainable Development*, November 1998.

Golombek and Hoel (2004): “Unilateral Emission Reductions and Cross-Country Technology Spillovers”, *Advances in Economic Analysis & Policy* 4 No. 2, article 3

Government of India Homepage: <http://envfor.nic.in/cc/cdm/criteria.htm>

Haites, E., M. Duan and S. Seres (2006): “Technology transfer by CDM projects”, BASIC Project paper, Margaree Consultants Inc.

Haake, F. (2006): *Technology Transfer and the Clean Development Mechanism: Is it true?* Diplomarbeit, the University of Applied Sciences of Flensburg and the Energy Research Centre of the Netherlands (ECN)

IEA (International Energy Agency) (2001): *Technology Without Borders: Case Studies of Successful Technology Transfer*. OECD/IEA.

IGES (2005): CDM Country Guide for Cambodia. Edited by Institute for Global Environment Strategies, 2nd Edition.

IPCC (1995): *Climate Change 1995: Second Assessment*. IPCC WGI Second Assessment Report.

IPCC (2000): *Methodological and Technological issues in Technology Transfer*. Special Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, U.K.

IPCC (2001): *Climate Change 2001: The Scientific Basis*. IPCC WGI Third Assessment Report.

IPCC (2007): “Climate Change 2007: The Physical Science Basis. Summary for Policymakers”, IPCC WGI Fourth Assessment Report.

Kallbekken, S. (2006): “Why the CDM will reduce carbon leakage”, *Climate Policy* No. 6 (3).

Kaplinsky, R. (1990): “Technology transfer, adaptation and generation: A framework for evaluation”, in Chatterji (ed.): *Technology Transfer in the Developing Countries*. New York, St. Martin’s Press, 19–26.

Keller, W. (2001): “International technology diffusion”, NBER Working Paper Series, Working Paper No. 8573

Keller, W. (2004): “International technology diffusion”, *Journal of Economic Literature*, Vol. 42 No. 3, 752-782.

- Kline, D.M, L. Vimmerstedt and R. Benioff (2004): “Clean energy technology transfer: A review of programs under the UNFCCC”, *Mitigation and Adaptation Strategies for Global Change* 9, Kluwer Academic Publishers, 1–35.
- Lichtenberg, F. and B. van Pottelsberghe de la Potterie (2001): “Does Foreign Direct Investment transfer technology across borders?” *The Review of Economics and Statistics* 83 No. 3, 490-497
- Magill, F.N. (ed.) (1997): *International Encyclopedia of Economics, Volume two*. Salem Press Inc., Fitzroy Dearborn publishers, 1542.
- Michaelowa, A. and M. Dutschke (1999): “Economic and Political Aspects of Baselines in the CDM Context”. In Goldemberg, J. and W. Reid (eds): *Promoting development while limiting greenhouse gas emissions: trends & baselines*. United Nations Development Programme and World Resources Institute, New York, 115-134.
- Michaelowa, A. and F. Jotzo (2005): “Transaction costs, institutional rigidities and the size of the clean development mechanism”, *Energy Policy* No. 33, 511–523.
- NC CDM (National Commission for CDM) in Indonesia Homepage: <http://dna-cdm.menlh.go.id/en/>
- Nordqvist, J. (2005): “Climate Change and Industrial Technology Transfer - A study of Chinese conditions”, Thesis for the Degree of Doctor of Philosophy in Engineering, Lund University, Sweden.
- Pearce, D.W. (1992): *Macmillan dictionary of modern economics (4th ed.)*. Aberdeen Economic Consultants, The Macmillan Press LTD, 424
- Pembina Institute (2003): *A User's Guide to the CDM*. Pembina Institute for Appropriate Development.
- Point Carbon 28.03.07: www.pointcarbon.com
- Point Carbon (2007): *Carbon 2007. A new climate for carbon trading*. Point Carbon.
- Polanyi, M. (1958): *Personal knowledge; towards a post-critical philosophy*. University of Chicago Press, Chicago IL.
- Rodrik, D. (1991): “Policy uncertainty and private investment in developing countries”, *Journal of Development Economics* No. 36, 229-242. North-Holland

Teece, D. (1977): “Technology Transfer by Multinational Firms: The Resource Cost of Transferring Technological Know-How”, *Economic Journal* No. 87, 242-61.

TERI (2005): CDM Implementation in India – the National Strategy Study. The Energy and Resources Institute.

TERI (2006): “The Clean Development Mechanism and Technological Change”, Version 2.0, 13th June 2006.

TT:Clear Homepage: <http://ttclear.unfccc.int>

UNDP Homepage: <http://www.undp.org>

UNEP DTIE Homepage : <http://www.unepdtie.org/>

UNFCCC (1992): “United Nations Framework Convention on Climate Change”, United Nations.

UNFCCC (1998a): “Kyoto Protocol to the United Nations Framework Convention on Climate Change”, United Nations.

UNFCCC (1998b): “Technical Paper on Terms of Transfer of Technology and know-how - Barriers and opportunities related to the transfer of technology”, FCCC/TP/1998/1, United Nations.

UNFCCC Homepage: <http://unfccc.int>

UNFCCC (2005) - “Guidelines for completing the project description document (CDM-PDD), and the proposed new baseline and monitoring methodologies (CDM-NM)”

UNFCCCstat - <http://cdm.unfccc.int/Statistics/index.html>

U.S. EPA Homepage: www.epa.gov

Wikipedia: www.wikipedia.org

Wilkins, G. (2002): *Technology Transfer for Renewable Energy – Overcoming Barriers in Developing Countries*. Royal Institute of International Affairs, London

Woerdman, E. (2004): *The Institutional Economics of Market-Based Climate Policy*. Elsevier B. V.

WWF Homepage: <http://www.panda.org>